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<b>(21) International Application Number:</b> PCT/US92/08478 <b>(22) International Filing Date:</b> 9 October 1992 (09.10.92)  <b>(30) Priority data:</b> 773,097 10 October 1991 (10.10.91) US  <b>(60) Parent Application or Grant</b> (63) Related by Continuation US 773,097 (CIP) Filed on 10 October 1991 (10.10.91)  <b>(71)(72) Applicant and Inventor:</b> PANG, Peter, K., T. [US/CA]; 52225 Range Road 232, 205 Carriage Lane, Sherwood Park, Alberta T8A 2A6 (CA).		<b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only) :</b> SHAN, Jie [CN/CA]; 10615-83 Avenue, #105, Edmonton, Alberta T6E 2E3 (CA).  <b>(74) Agent:</b> MURRAY, Robert, B.; Nikaido, Marmelstein, Murray & Oram, Metropolitan Square, Suite 330, G Street Lobby, 655 15th Street, N.W., Washington, DC 20005-5701 (US).  <b>(81) Designated States:</b> AT, AU, BB, BG, BR, CA, CH, CS, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, PL, RO, RU, SD, SE, US, Euro- pean patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> PARATHYROID HORMONE ANALOGUES AND USE IN OSTEOPOROSIS TREATMENT  <b>(57) Abstract</b>  Analogues of bovine and human parathyroid hormone, wherein the twenty-third amino acid of the natural hormone, tryptophane, has been substituted with Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Lys, Met, Pro, Ser or Thr have been found to retain bone cell effect with minimal effects on blood pressure and smooth muscle, including cardiac muscle. It has further been found that this effect can be obtained by using a synthetic PTH containing only the first 34 amino acids of PTH, with substitution at the twenty-third amino acid as described. These analogues of PTH also are effective in the treatment of osteoporosis and other bone diseases.		

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PARATHYROID HORMONE ANALOGUES AND  
USE IN OSTEOPOROSIS TREATMENT

FIELD OF THE INVENTION

This invention relates to analogues of parathyroid hormone which, by substitution at the twenty-third position of natural parathyroid hormone, have been found to affect calcium change in bone cells without producing the typical effects of parathyroid hormone on systolic and diastolic blood pressure, the effects on smooth muscle relaxation, vascular smooth muscle calcium change as well as positive chronotropic and inotropic effects on the heart.

BACKGROUND OF THE INVENTION

Parathyroid hormone (hereinafter, PTH) is produced by the parathyroid gland and is involved in the control of calcium levels in blood. It is a hypercalcemic hormone, elevating blood calcium levels. PTH is a polypeptide and the amino acid sequences of bovine and human PTH are closely related. Only the residues at locations one, seven and sixteen differ between the two. Synthetic polypeptides containing the first thirty-four residues of PTH may be prepared using the method disclosed by Erickson and Merrifield, The Proteins, Neurath et al., Eds., Academic Press, New York, 1976, page 257, preferably as modified by the method of Hodges et al., Peptide Research, 1, 19 (1988).

When serum calcium is reduced to below a "normal" level, the parathyroid gland releases PTH and resorption of bone calcium and increased absorption of calcium from the intestine, as well as renal reabsorption of calcium, occur.

The antagonist of PTH is calcitonin, which acts to reduce the level of circulating calcium. PTH is known to stimulate osteoclasts and its activity requires the presence of derivatives of vitamin D<sub>3</sub>, especially 1,25-

dihydroxycholecalciferol.

Intracellular calcium, particularly in the cells of the vascular system, has been shown to affect changes in vascular tension, as can be measured by changes in blood pressure. U.S. Patent Application 603,745 describes one method which has been discovered to regulate calcium uptake in vascular cells.

Osteoporosis is a progressive disease which is particularly characteristic of postmenopausal women, and results in the reduction of total bone mass. The sequelae frequently involve fractures of load-bearing bones and the physical degenerations characteristic of immobilizing injuries. Osteoporosis is associated with hyperthyroidism, hyperparathyroidism, Cushings syndrome and the use of certain steroidal drugs. Remedies historically have involved increase in dietary calcium, estrogen therapy and increased doses of vitamin D.

PTH has been used to treat osteoporosis. However, while the use of PTH is effective in the treatment of osteoporosis by diminishing the loss of bone mass, PTH may exhibit other undesired pharmacological effects, such as hypotension and smooth muscle relaxation (e.g. relaxation of gastrointestinal organs, uterus, tracheal and vas deferens) as well as positive chronotropic and inotropic effects on the heart. The relaxation effects of PTH on smooth muscle as well as positive chronotropic and inotropic effects of PTH are described in Pang et al, Trends in Pharmacological Sciences, Vol. 7, No. 9, pp. 340-341 (September 1986).

U.S. Patent No. 4,771,124 discloses the property of bovine and human PTH analogues wherein Trp<sup>23</sup> is substituted by amino acids phenylalanine, leucine, norleucine, valine, tyrosine, beta-naphtylalanine and alpha-naphtylalanine as a PTH antagonist. While it was suggested that these analogues might be useful in the treatment of osteoporosis, it was based on the analogues antagonistic action to PTH. Furthermore, there was no data to indicate the effectiveness these analogues on bone or other tissue. In addition, analogues with substituted at

Trp<sup>23</sup> with leucine, phenylalanine or tyrosine would produce undesired secondary effects of smooth muscle relaxation, vascular smooth muscle calcium change as well as positive chronotropic and inotropic effects on the heart.

5           Because PTH is a peptide, topical administration would be the preferred method of administration. However, topical application of PTH or the aforementioned analogues which exhibit vasoactivity would likely produce an undesired local vascular reaction. This reaction could be potentially  
10           detrimental if, for example, nasal administration is employed.

          It is one object of this invention to ameliorate bone loss while preventing smooth muscle relaxation as well as positive chronotropic and inotropic effects on the heart and without significantly changing blood pressure. It is another object of  
15           this invention to identify that portion of PTH which is responsible for calcium regulation and that portion which appears to be primarily related to control of blood pressure and smooth muscle action.

#### BRIEF SUMMARY OF THE INVENTION

20           Modification of either bovine or human PTH at the twenty-third amino acid position to substitute for tryptophane either alanine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, lysine, methionine, proline, serine or threonine produces  
25           essentially no change in systolic and diastolic blood pressure, no change in smooth muscle tension and no change in the rate and force of contraction of the heart as compared to native PTH. It also has been observed that the PTH analogue containing only the first thirty-four amino acids, with  
30           substitution at the twenty-third position, is equally effective in increasing the "osteo effect" without changing blood pressure or causing smooth muscle relaxation or positive chronotropic and inotropic effects on the heart.

          The analogues of the present invention should be effective  
35           in ameliorating bone loss while preventing smooth muscle

relaxation as well as positive chronotropic and inotropic effects on the heart and without significantly changing blood pressure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1a shows the structure of natural bovine PTH (SEQ ID NO:1).

Fig. 1b shows the structure of natural human PTH (SEQ ID NO:2).

10 Fig. 2a shows the structure of bPTH (1-34) with position 23 substituted with Xaa (SEQ ID NO:3).

Figs. 2b-2p show the structure of bPTH (1-34) with position 23 substituted with Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Lys, Met, Pro, Ser or Thr, respectively (SEQ ID NO:4 - SEQ ID NO:18).

15 Fig. 3a shows the structure of hPTH (1-34) with position 23 substituted with Xaa (SEQ ID NO:19).

20 Figs. 3b-3p show the structure of hPTH (1-34) with position 23 substituted with Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Lys, Met, Pro, Ser or Thr, respectively (SEQ ID NO:20 - SEQ ID NO:34).

Fig. 4 shows the structure of bPTH with position 23 substituted with Xaa (SEQ ID NO:35).

Fig. 5 shows the structure of hPTH with position 23 substituted with Xaa (SEQ ID NO:36).

25 Fig. 6 shows the effect of bPTH-(1-34) and its analogues on diastolic blood pressure of anesthetized Sprague-Dawley rats. Cs114 had no effect.

30 Fig. 7 shows the effect of bPTH-(1-34) and its analogues on systolic blood pressure of anesthetized Sprague-Dawley rats. Cs114 had no effect.

Fig. 8 shows the vasorelaxing effect of bPTH-(1-34) and its analogues on rat tail artery helical strip in vitro. Cs114 had no effect.

35 Fig. 9 shows the depolarizing concentrations of KCl which increased calcium ion levels in cultured osteoblasts. Drug 788 is an anti-osteoporotic agent which inhibits the KCl effect.

Figs. 10 a-d show the depolarizing concentrations of KCl which increased calcium levels in cultured osteoblasts. Addition of bPTH-(1-34) inhibits the KCl effect.

5 Figs. 11 a-c show the depolarizing concentrations of KCl increasing calcium ion levels in cultured osteoblasts. Cs114 inhibits the KCl effect.

Fig. 12 shows the relation between the relaxation curves of Sprague-Dawley rat tail artery helical strips, precontracted with AVP when treated with Cs114, Cs117 and Cs201.

10 Fig. 13 shows the effects illustrated in Fig. 12, using Cs206, Cs207, Cs501, Cs502 and Cs503.

Fig. 14 shows the relaxation curves produced by Cs117, Cs201, Cs501, Cs502 and Cs503 on rat tail artery helical strips precontracted with KCl.

15 Fig. 15 shows the relationship between the tension of rat tail artery helical strips depolarized with  $10^{-7}$  M NE, as a function of calcium concentration in the presence of Cs114.

20 Fig. 16 shows the effect of Cs114 on the intracellular calcium concentration in the presence of KCl in UMR cells in culture.

Fig. 17 shows a comparison of the effect of Cs205 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

25 Fig. 18 shows the dose-response relationship between Cs205 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

Fig. 19 shows a comparison of the effect of Cs201 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

30 Fig. 20 shows the dose-response relationship between Cs201 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

35 Fig. 21 shows a comparison of the effect of Cs503 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

Fig. 22 shows the dose-response relationship between Cs503 and the tension of rat tail artery helical strips precontracted

with KCl, norepinephrine and AVP.

Fig. 23 shows a comparison of the effect of Cs502 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

5 Fig. 24 shows the dose-response relationship between Cs502 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

10 Fig. 25 shows a comparison of the effect of Cs501 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

Fig. 26 shows the dose-response relationship between Cs501 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

15 Fig. 27 comparison of the effect of Cs207 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

Fig. 28 shows the dose-response relationship between Cs207 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

20 Fig. 29 shows the effect of Cs207 on intracellular calcium increase stimulated by KCl in cultured UMR osteoblast cells.

Fig. 30 shows the effect of Cs207 on intracellular calcium increase stimulated by KCl in cultured UMR cells.

25 Fig. 31 shows a comparison of the effect of Cs206 and bPTH on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

Fig. 32 shows the dose-response relationship between Cs206 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

30 Fig. 33 shows the effect of Cs206 on intracellular calcium concentration stimulated by KCl in cultured UMR osteoblast cells.

Fig. 34 shows the effect of Cs206 on intracellular calcium concentration stimulated by KCl in cultured UMR cells.

35 Fig. 35 shows a comparison of the effect of Cs114 and bPTH on the systolic blood pressure of anesthetized Sprague-Dawley rats.

Fig. 36 shows a comparison of the effect of Cs114 and bPTH on the diastolic blood pressure of anesthetized Sprague-Dawley rats.

5 Fig. 37 shows the dose-response relationship between Cs114 and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

Fig. 38 shows the effect of Cs114 on intracellular calcium concentration stimulated by KCl in cultured UMR osteoblast cells.

10 Fig. 39 shows the effect of Cs114 (A) on intracellular calcium concentration stimulated by KCl in cultured UMR cells at 15 mM KCl.

15 Fig. 40 shows the effect of Cs114 (B) on intracellular calcium concentration stimulated by KCl in cultured UMR cells at 30 mM KCl.

Fig. 41 shows the effect of Cs88 [bPTH-(1-34)] on the mean arterial blood pressure of anesthetized Sprague-Dawley rats.

20 Fig. 42 shows the dose-response relationship between Cs88 [bPTH-(1-34)] and the tension of rat tail artery helical strips precontracted with KCl, norepinephrine and AVP.

Fig. 43 shows the effect of Cs88 on intracellular calcium concentration stimulated by KCl in cultured UMR osteoblast cells.

25 Fig. 44 shows the effect of Cs88 on intracellular calcium concentration stimulated by KCl in cultured UMR cells.

Fig. 45 shows the effect of Cs113 on the intracellular calcium concentration stimulated by KCl in the presence of KCl in UMR cells in culture.

30 Fig. 46 shows the effect of Cs501 on the intracellular calcium concentration stimulated by KCl in the presence of KCl in UMR cells in culture.

Fig. 47 shows the effect of Cs1001 on the intracellular calcium concentration stimulated by KCl in the presence of KCl in UMR cells in culture.

35 Fig. 48 shows the effect of Cs114 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 49 shows the effect of Cs201 on the contractility and

contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 50 shows the effect of Cs205 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 51 shows the effect of Cs206 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 52 shows the effect of Cs207 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 53 shows the effect of Cs208 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 54 shows the effect of Cs209 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 55 shows the effect of Cs211 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 56 shows the effect of Cs212 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 57 shows the effect of Cs213 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 58 shows the effect of Cs214 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 59 shows the effect of Cs215 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 60 shows the effect of Cs220 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 61 shows the effect of Cs501 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 62 shows the effect of Cs503 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 63 shows the effect of Cs2001 and Cs1001 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 64 shows the effect of Cs219 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 65 shows the effect of Cs218 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

Fig. 66 shows the effect of Cs502 on the contractility and contraction rate of right atrial tissue of Sprague-Dawley rats.

DETAILED DESCRIPTION OF THE INVENTION

There are at least two known categories of functions for PTH. PTH is involved in calcium balance in the blood stream and controls both the amount of calcium uptake from the gastrointestinal tract and the deposition and removal of calcium from bone. Calcium also has been found to be effective in the maintenance of blood pressure. Cox, J. Cardiovascular Pharmacology, Vol. 8 (1986), Supp. 8 S48. Control of calcium in the walls of blood vessels is a useful therapeutic regimen for controlling hypertension and calcium channel blockers, which prevent the introduction of calcium into cell walls, is a conventional therapy for hypertension. Needleman et al. in Goodman and Gilman's The Pharmacological Basis of Therapeutics, MacMillan, New York, (1985), page 816 ff.

Administration of therapeutic doses of PTH has been found to be effective for the control of osteoporosis, particularly in individuals who have been subjected to thyroidectomies/parathyroidectomies. Therapeutic dosages of PTH will, in some individuals, result in unacceptable diminution of blood pressure and may result in relaxation of smooth muscles such as gastrointestinal, uterus, tracheal, vas deferens as well as exhibit positive chronotropic and inotropic effects on the heart. To avoid hypotensive effects, smooth muscle relaxation effects and positive chronotropic and inotropic effects on the heart, it was envisaged that the structure of PTH could be modified to decouple the hypotensive, smooth muscle relaxation and positive chronotropic and inotropic function from the bond calcium and bone deposition function. It has now been discovered that a critical site exists at amino acid twenty-three, which is tryptophane (Trp) in both bovine and human PTH. Substitution at the Trp site with other amino acids diminishes the hypotensive, smooth muscle relaxation and positive chronotropic and inotropic effects without denigrating from the osteo effect. Particularly effective in this regard, is the substitution of alanine (Ala) or other amino acids for Trp.

The procedure of Erickson and Merrifield, as modified by

Hodges et al., as described above, may be used to synthesize synthetic PTH or fragments thereof. The procedure enables substitution for the naturally occurring PTH at substantially every location and it is possible to prepare both bovine and human synthetic PTH at full length or in the sequence of the first thirty-four amino acids, which is more facilely performed. Such substitution can also be accomplished by genetic engineering.

Substitution at position twenty-three invariably alters the observed hypotensive, smooth muscle relaxation and positive chronotropic and inotropic effects, whether the full length PTH or the 1-34 fragment is administered. Substitution of Ala for Trp at position twenty-three is particularly preferred because the change in blood pressure, smooth muscle relaxation and positive chronotropic and inotropic effects from this substitution are minimal and calcium uptake, as measured in osteoblasts, mimics the results from the administration of native PTH. The 1-34 PTH fragment with Ala<sup>23</sup> or other amino acids is particularly preferred because the pharmacological properties are those which are desired and the difficulty of synthesis is minimized. Synthesis of the compounds used in the development of this invention was performed at Alberta Peptide Institute (API) and the cooperation of API is gratefully acknowledged.

The structure of bovine parathyroid hormone (bPTH) and human parathyroid hormone (hPTH) are shown in Figs. 1a (SEQ ID NO:1) and 1b (SEQ ID NO:2). Representative synthetic analogues are described in Table 1 and are further shown in Figs. 2-5 and SEQ ID NO:3-SEQ ID NO:36. The hypotensive effects of these analogues is shown in Figs. 6, 7, 17, 19, 21, 23, 25, 27, 31, 35, 36, and 41. All of the analogues produce either no or less diminution of blood pressure than does native PTH. The Ala<sup>23</sup> analogue provides almost no change in blood pressure, either systolic or diastolic, over a range of 0-5  $\mu$ g/kg. At the level of 5  $\mu$ g/kg of PTH, the blood pressure in Sprague-Dawley rats is such that they are essentially moribund.

We have developed a method for modeling the hypotensive

effects of natural and synthetic chemical compounds using helically cut tail arteries from Sprague-Dawley rats in a Sawyer-Bartlestone chamber, measuring the change in tension with a force displacement transducer. This method and the effect of bovine PTH-(1-34) in this system is described in Blood Vessels, 22, 57 (1985). It is demonstrated in this paper that bPTH-(1-34) produces dose-dependent relaxation of helical strips of rat tail artery which have been previously contracted using arginine-vasopressin (AVP). Figs. 8, 12, 15, 18, 20, 22, 24, 26, 28, 32, 37 and 42 illustrate the effect of the PTH analogues of this invention as measured using this in vitro technique. Alternatively, the strips may be precontracted using other pressor substances such as norepinephrine (NE) or KCl.

We have also developed a method of modeling the chronotropic effects of natural and synthetic chemicals using the right atrium from Sprague-Dawley rats and measuring the change in the force and rate of atrium contraction. This method and the effects of bovine PTH (1-34) in this system are described in Tenner et al, The Canadian Journal of Physiology and Pharmacology, Volume 61, No. 10 (1983) pp. 1162-1167. It is demonstrated in this paper that bPTH (1-34) produces significant dose-dependent chronotropic effects on rat cardiac pacemaker tissue. Figs. 48-66 illustrate the effect of the PTH analogues of this invention as measured using this in vitro technique.

Because osteoporosis is a progressive syndrome, a model is required and the use of cultured osteoblasts of the UMR-106 rat osteosarcoma cells, ATCC CRL 1661 have been used as the model. Intracellular calcium concentration change in these cells has been monitored using the FURA-2 method, wherein a fluorescent dye which is specific for calcium is used as a marker for calcium uptake into the cells. Cells are incubated with 1-10  $\mu$ M of the acetomethoxy ester of FURA-2 for 30-60 minutes. Upon uptake, the ester is hydrolyzed to release free FURA-2, which selectively binds free  $\text{Ca}^{2+}$ . FURA-2 has a characteristic fluorescence spectrum, which wavelength is shifted when the dye

binds to free  $\text{Ca}^{2+}$ . According to the method,  $\text{Ca}^{2+}$  which is present in the cell can be quantified by exciting the dye at two different wavelengths, 340 and 380 nm. The emission fluorescence is measured at 510 nm. The calcium concentration is proportional to the ratio of the fluorescent emission when excited at 340 nm to the emission at 380 nm. It is conventional to report the concentration of calcium within the cell in terms of the fluorescence ratio, the 340/380 ratio. This technique is described in Gryniewicz et al., J. Biol. Chem., 260, 3440 (1985) and Pang et al., P. N. A. S. (USA), 87, 623 (1990).

Figs. 9, 10 a-d, 11 a-c, 16, 29, 30, 33, 34, 38, 39, 40, 43, 44 and 45-47 illustrate the results of the above-described measurements when inhibitors such as an anti-osteoporotic agent (788) or bPTH-(1-34) or Cs114 were used in the presence of KCl.

As can be readily seen from the figures, the PTH analogues, whether full length or 1-34, which contain anomalous amino acids at position twenty-three (most particularly those which contain Ala<sup>23</sup>) do not effect a hypotensive and smooth muscle relaxation response, including positive chronotropic effects, but do inhibit calcium uptake as stimulated by KCl in osteoblasts, which indicates that these compounds would have the same effect on bone cells as PTH and would be useful in the treatment of osteoporosis in mammals and, particularly, in man, without the aforementioned deleterious side effects in the elderly.

While not being bound by any theory, it is suggested that substitution of Trp<sup>23</sup> by other amino acids in 1-84 PTH and in the 1-34 analogues removes the vasodepressor, smooth muscle relaxation and positive chronotropic and inotropic effects of either bPTH or hPTH. The effect on KCl induced in osteoblasts, however, is essentially unchanged for 1-84 or 1-34 PTH. In other words, the effect on bone cells is unchanged from PTH.

The physiological significance of an inhibiting effect on the KCl induced calcium uptake in bone cells is not yet understood. One hypothesis is that the analogues interact fully with bone cell receptor activity. The fact that the same

effect is seen for both PTH and the analogues disclosed herein suggests that the site of interaction with the osteoblast cell receptor is unchanged by the substitution.

The analogues of the present invention can be used in the treatment of osteoporosis and other bone related diseases and disorders involving bone cell calcium regulation.

The analogues of the present invention may be administered to a warm-blooded mammalian in need thereof, particularly a human, by parental, topical, rectal administration or by inhalation. The analogues may be conventionally formulated in a parenteral dosage form compounding about 1 to about 300 mg per unit of dosage with a conventional vehicle, excipient, binder, preservative, stabilizer, color, agent or the like as called for by accepted pharmaceutical practice.

For parental administration, a 1 to 10 ml intravenous, intramuscular or subcutaneous injection would be given one to four times daily. The injection would contain an analogue of the present invention in an aqueous isotonic sterile solution or suspension optionally with a preservative such as phenol or a solubilizing agent such as ethylenediaminetetraacetic acid (EDTA). Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. Synthetic monoglycerides, diglycerides, fatty acids (such as oleic acid) find use as fixed oil in the preparation of injectables.

For rectal administration, the analogues of the present invention can be prepared in the form of suppositories by mixing with a suitable non-irritating excipient such as cocoa butter or polyethylene glycols.

For topical use, the analogues of the present invention can be prepared in the form of ointments, jellies, solutions, suspensions or dermal adhesive patches.

In a powdered aerosol, analogues of the present invention may be administered by a spinhaler turbo-inhaler device obtained from Fisons Corporation of Bedford, Massachusetts, at

a rate of about 0.1 to 50 mg per capsule, 1 to 8 capsules being administered daily for an average human. In a liquid aerosol, the compounds of the present invention are administered at the rate of about 100 to 1000 micrograms per "puff" or activated  
5 release of a standard volume of propellant. The liquid aerosol would be given at the rate of 1 to 8 "puffs" per day with variation in dosages due to the severity of the conditions being treated, the weight of the patient and the particle size distribution of the aerosol. A fluorinated hydrocarbon or  
10 isobutane find use as propellants for liquid aerosols.

Daily doses are in the range of about 0.01 to about 200 mg per kg of body weight, depending on the activity of the specific compound, the age, weight, sex and conditions of the subject to be treated, the type and severity of the disease,  
15 the frequency and route of administration. As would be well known, the amount of active ingredient that may be combined with the carried materials to produce a single dosage will vary depending upon the host treated and the particular mode of administration.

20 The following examples demonstrate the utility of applicants' invention. The examples are not limiting, but are illustrative only, and modifications which would be apparent to those skilled in the art are included within the scope of this disclosure.

Example 1In Vivo Blood Pressure Measurement.

Sprague-Dawley (S-D) rats were anaesthetized with pentobarbital and a cannula was inserted into the carotid artery. The rats were kept sedated during the procedure and were injected with PTH peptides only when the blood pressure of the rats were stable. Peptides were injected through a cannula in the jugular vein, in amounts of 1, 3 and 5 or more  $\mu\text{g/kg}$  and the mean systolic and diastolic blood pressure was monitored continuously throughout the procedure. Results are reported with comparison to bPTH-(1-34).

Example 2In Vitro Rat Tail Artery Helical Strip Tension Assay

The assay was performed according to Pang et al., Blood Vessels, 22, 57 (1985). Sprague-Dawley rats were anaesthetized with pentobarbital and the tail artery excised and placed in ice-cold Krebs-Hanseleit solution (KHS) oxygenated with 95%  $\text{O}_2$ , 5%  $\text{CO}_2$ . Each artery was cut helically and strips of approximately 1.5 cm were secured in a Sawyer-Bartlestone chamber containing KHS. The force generated by the strips was measured with a Grass FT03 force displacement transducer and recorded on a polygraph. Isolated tail artery helical strips were equilibrated for 1 hour prior to use.

One to two minutes prior to addition of a peptide, the strips were contracted by addition of either arginine vasopressin (AVP), potassium chloride (KCl) or norepinephrine (NE) to the bath. The peptide was then added to the bath and the degree of relaxation measured. Bovine serum albumin was used as a control. Results are reported as percent decrease in tension for each drug and dose used. Drug dose is calculated on the basis of the final concentration in the bath solution.

Example 3In Vitro atrial contractility and contraction rate measurement

The assay was performed according to Tenner et al., Canadian Journal of Physiology and Pharmacology, Vol. 61, No. 10 (1983) pp. 1162-1167. Sprague-Dawley rats weighing between

100 and 250 g were treated with heparin (500 IU, i.p.) 15 minutes prior to decapitation. Thoracotomies were performed and the heart rapidly excised and placed in a cold physiological salt solution (PSS) having the following composition (in millimolar): NaCl, 120; KCl, 5.63; CaCl<sub>2</sub>, 2.0; MgCl<sub>2</sub>, 2.1; NaHCO<sub>3</sub>, 25.0; dextrose, 9.7. The solution was continuously aerated by a gas mixture of 95% O<sub>2</sub>-5% CO<sub>2</sub>. The right atrium was isolated and suspended in a tissue chamber containing 20 mL of PSS at 37°C, pH 7.4. Atria were allowed to equilibrate for 1 hr under a resting tension of 1 g.

The atrial rate and force were determined from contractions recorded by a Grass FT.03 force-displacement transducer and a Grass model 79 polygraph. The Basal atrial rate for control atria (as determined by counting the frequency of contractions) was 258 ± 7 bpm (n=29). Basal developed force of the spontaneously beating right atria was 0.33 ± 0.06 g (n=10). Dose-response curves for the peptides were obtained by cumulative addition of the respective peptides. Drug dose is calculated on the basis of the final concentration in the bath solution.

#### Example 4

#### Measurement of Intracellular Free Calcium Concentration In Vitro

Intracellular free calcium concentration was measured using the fluorescent dye FURA-2 according to the method of Grynkiewicz et al., J. Biol. Chem., 260, 3440 (1985) and Pang et al., P. N. A. S. (USA), 87, 623 (1990). UMR-106 rat osteosarcoma cells (ATCC CRL-1661) are incubated in 1-10 μM FURA-2 AM (Sigma Chemical Co., St. Louis), the acetomethoxy ester of FURA-2. Upon hydrolysis within the cell, FURA-2 is released which selectively binds to free Ca<sup>2+</sup>. Binding to Ca<sup>2+</sup> shifts the fluorescent spectrum of FURA-2. Quantitation is obtained by exciting the dye at two different wavelengths, preferably 340 and 380 nm and measuring the fluorescent emission at 510 nm. The concentration of calcium is proportional to the ratio of the fluorescence emitted at 340 nm

to that at 380 nm.

KCl is used in the medium to stimulate  $\text{Ca}^{2+}$  uptake.

After the intracellular  $[\text{Ca}^{2+}]_i$  had been measured, the cells were washed with the original medium and the analogues added and the intracellular  $[\text{Ca}^{2+}]_i$  measured again. KCl was then added without washing to measure the effect of the analogue on KCl induced  $\text{Ca}^{2+}$  uptake. After measurement, the cells were washed with the medium 3-4 times and KCl again added to determine the recovery of the cells after removal of the analogue. Results are shown by actual traces and histograms summarizing the results. As can be seen from Figs. 10 a-d, PTH inhibits  $\text{Ca}^{2+}$  uptake as measured by the method. Figs. 11 a-c, 16, 29, 30, 33, 34, 38, 39, 40, 44 and 45-47 illustrate comparable results for the aa<sup>23</sup> analogues.

The comparability of the analogues and PTH itself is considered to indicate that the analogues would be as useful as PTH for the treatment of osteoporosis.

Table I

	<u>Designation</u>	<u>Length</u>	<u>Source</u>	<u>Substitution</u>	<u>Site</u>
	Cs88	1-34	bovine	none	
	Cs99	1-34	bovine	Ala	25
5	Cs100	1-34	bovine	Ala	26
	Cs114	1-34	bovine	Ala	23
	Cs117	1-34	bovine	Ala	27
	Cs201	1-34	human	Asp	23
	Cs205	1-34	human	Pro	23
10	Cs206	1-34	human	Asn	23
	Cs207	1-34	human	Thr	23
	Cs208	1-34	human	Ser	23
	Cs209	1-34	human	Glu	23
	Cs210	1-34	human	Gln	23
15	Cs211	1-34	human	Gly	23
	Cs212	1-34	human	Cys	23
	Cs213	1-34	human	Ile	23
	Cs214	1-34	human	Lys	23
	Cs215	1-34	human	His	23
20	Cs218	1-34	human	Tyr	23
	Cs219	1-34	human	Phe	23
	Cs220	1-34	human	Ala	23
	Cs501	1-34	human	Met	23
	Cs502	1-34	human	Leu	23
25	Cs503	1-34	human	Arg	23
	Cs1001	1-34	human	none	
	Cs2001	1-84	human	none	

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

(i) APPLICANT: PANG, Peter K.T.  
JIE, Shan

5 (ii) TITLE OF INVENTION: PARATHYROID HORMONE ANALOGUES AS  
OSTEOPOROTIC CONTROL AGENTS

(iii) NUMBER OF SEQUENCES: 36

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15 (v) COMPUTER READABLE FORM:

(A) MEDIUM TYPE: Floppy disk  
(B) COMPUTER: IBM PC compatible  
(C) OPERATING SYSTEM: PC-DOS/MS-DOS  
(D) SOFTWARE: PatentIn Release #1.0, Version #1.25

20 (vi) CURRENT APPLICATION DATA:

(A) APPLICATION NUMBER: US  
(B) FILING DATE:  
(C) CLASSIFICATION:

25 (viii) ATTORNEY/AGENT INFORMATION:

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## (2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

35 (A) LENGTH: 84 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

20

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Trp Leu Arg Lys Lys Leu Gln Asp Val His  
 5 20 25 30  
 Asn Phe Val Ala Leu Gly Ala Ser Ile Ala Tyr Arg Asp Gly Ser Ser  
 35 40 45  
 Gln Arg Pro Arg Lys Lys Glu Asp Asn Val Leu Val Glu Ser His Gln  
 50 55 60  
 Lys Ser Leu Gly Glu Ala Asp Lys Ala Asp Val Asp Val Leu Ile Lys  
 10 65 70 75 80  
 Ala Lys Pro Gln

## (2) INFORMATION FOR SEQ ID NO:2:

15 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 84 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## 20 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Trp Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe Val Ala Leu Gly Ala Ser Ile Ala Tyr Arg Asp Gly Ser Ser  
 25 35 40 45  
 Gln Arg Pro Arg Lys Lys Glu Asp Asn Val Leu Val Glu Ser His Gln  
 50 55 60  
 Lys Ser Leu Gly Glu Ala Asp Lys Ala Asp Val Asp Val Leu Ile Lys  
 30 65 70 75 80  
 Ala Lys Pro Gln

21

## (2) INFORMATION FOR SEQ ID NO:3:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15  
Ser Met Glu Arg Val Glu Xaa Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30  
Asn Phe

## (2) INFORMATION FOR SEQ ID NO:4:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15  
Ser Met Glu Arg Val Glu Ala Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30  
Asn Phe

## (2) INFORMATION FOR SEQ ID NO:5:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

22

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

Ser Met Glu Arg Val Glu Arg Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

Ser Met Glu Arg Val Glu Asn Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

Ser Met Glu Arg Val Glu Asp Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

23

## (2) INFORMATION FOR SEQ ID NO:8:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15

Ser Met Glu Arg Val Glu Cys Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:9:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15

Ser Met Glu Arg Val Glu Gln Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:10:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

24

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Glu Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe

## (2) INFORMATION FOR SEQ ID NO:11:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Gly Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe

## (2) INFORMATION FOR SEQ ID NO:12:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15  
 Ser Met Glu Arg Val Glu His Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe

25

## (2) INFORMATION FOR SEQ ID NO:13:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

Ser Met Glu Arg Val Glu Ile Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:14:

15

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

20

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

Ser Met Glu Arg Val Glu Lys Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

25

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:15:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

26

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15

Ser Met Glu Arg Val Glu Met Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15

Ser Met Glu Arg Val Glu Pro Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15

Ser Met Glu Arg Val Glu Ser Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

27

## (2) INFORMATION FOR SEQ ID NO:18:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
1 5 10 15

10 Ser Met Glu Arg Val Glu Thr Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:19:

15

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

20

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
1 5 10 15

Ser Met Glu Arg Val Glu Xaa Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

25

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:20:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

28

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Ala Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Arg Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Asn Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:23:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
1 5 10 15

10 Ser Met Glu Arg Val Glu Asp Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:24:

15

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

20

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
1 5 10 15

Ser Met Glu Arg Val Glu Cys Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30

25

Asn Phe

## (2) INFORMATION FOR SEQ ID NO:25:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

30

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Gln Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:26:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Glu Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Gly Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

31

## (2) INFORMATION FOR SEQ ID NO:28:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15  
 Ser Met Glu Arg Val Glu His Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe

## (2) INFORMATION FOR SEQ ID NO:29:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Ile Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe

## (2) INFORMATION FOR SEQ ID NO:30:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

32

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Lys Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Met Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

(2) INFORMATION FOR SEQ ID NO:32:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 34 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15

Ser Met Glu Arg Val Glu Pro Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30

Asn Phe

33

## (2) INFORMATION FOR SEQ ID NO:33:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:33:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
1 5 10 15  
Ser Met Glu Arg Val Glu Ser Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30  
Asn Phe

## (2) INFORMATION FOR SEQ ID NO:34:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 34 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:34:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
1 5 10 15  
Ser Met Glu Arg Val Glu Thr Leu Arg Lys Lys Leu Gln Asp Val His  
20 25 30  
Asn Phe

## (2) INFORMATION FOR SEQ ID NO:35:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 84 amino acids  
(B) TYPE: amino acid  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

34

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:35:

Ala Val Ser Glu Ile Gln Phe Met His Asn Leu Gly Lys His Leu Ser  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Xaa Leu Arg Lys Lys Leu Gln Asp Val His  
 5 20 25 30  
 Asn Phe Val Ala Leu Gly Ala Ser Ile Ala Tyr Arg Asp Gly Ser Ser  
 35 40 45  
 Gln Arg Pro Arg Lys Lys Glu Asp Asn Val Leu Val Glu Ser His Gln  
 50 55 60  
 Lys Ser Leu Gly Glu Ala Asp Lys Ala Asp Val Asp Val Leu Ile Lys  
 10 65 70 75 80  
 Ala Lys Pro Gln

## (2) INFORMATION FOR SEQ ID NO:36:

15 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 84 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## 20 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:36:

Ser Val Ser Glu Ile Gln Leu Met His Asn Leu Gly Lys His Leu Asn  
 1 5 10 15  
 Ser Met Glu Arg Val Glu Xaa Leu Arg Lys Lys Leu Gln Asp Val His  
 20 25 30  
 Asn Phe Val Ala Leu Gly Ala Ser Ile Ala Tyr Arg Asp Gly Ser Ser  
 25 35 40 45  
 Gln Arg Pro Arg Lys Lys Glu Asp Asn Val Leu Val Glu Ser His Gln  
 50 55 60  
 Lys Ser Leu Gly Glu Ala Asp Lys Ala Asp Val Asp Val Leu Ile Lys  
 30 65 70 75 80  
 Ala Lys Pro Gln

CLAIMS

1. A bovine parathyroid hormone analogue comprising the structure shown in SEQ ID NO:3, wherein Xaa is Alanine (Ala), Arginine (Arg), Asparagine (Asn), Aspartic acid (Asp), Cysteine (Cys), Glutamine (Gln), Glutamic acid (Glu), Glycine (Gly), Histidine (His), Isoleucine (Ile), Lysine (Lys), Methionine (Met), Proline (Pro), Serine (Ser) or Threonine (Thr).

2. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:4.

3. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:5.

4. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:6.

5. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:7.

6. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:8.

7. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:9.

8. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:10.

9. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:11.

10. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:12.

11. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:13.

12. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:14.

13. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:15.

14. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:16.

15. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:17.

16. The bovine parathyroid hormone analogue having the structure shown in SEQ ID NO:18.

17. A human parathyroid hormone analogue comprising the structure shown in SEQ ID NO:19, wherein Xaa is Alanine (Ala), Arginine (Arg), Asparagine (Asn), Aspartic acid (Asp), Cysteine (Cys), Glutamine (Gln), Glutamic acid (Glu), Glycine (Gly), Histidine (His), Isoleucine (Ile), Lysine (Lys), Methionine (Met), Proline (Pro), Serine (Ser) or Threonine (Thr).

18. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:20.

19. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:21.

20. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:22.

21. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:23.

22. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:24.

23. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:25.

24. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:26.

25. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:27.

26. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:28.

27. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:29.

28. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:30.

29. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:31.

30. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:32.

31. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:33.

32. The human parathyroid hormone analogue having the structure shown in SEQ ID NO:34.

33. A bovine parathyroid hormone analogue comprising the structure shown in SEQ ID NO:35, wherein Xaa is Alanine (Ala), Arginine (Arg), Asparagine (Asn), Aspartic acid (Asp), Cysteine (Cys), Glutamine (Gln), Glutamic acid (Glu), Glycine (Gly),

Histidine (His), Isoleucine (Ile), Lysine (Lys), Methionine (Met), Proline (Pro), Serine (Ser) or Threonine (Thr).

34. A human parathyroid hormone analogue comprising the structure shown in SEQ ID NO:36, wherein Xaa is Alanine (Ala), Arginine (Arg), Asparagine (Asn), Aspartic acid (Asp), Cysteine (Cys), Glutamine (Gln), Glutamic acid (Glu), Glycine (Gly), Histidine (His), Isoleucine (Ile), Lysine (Lys), Methionine (Met), Proline (Pro), Serine (Ser) or Threonine (Thr).

35. A pharmaceutical composition comprising a PTH analogue according to any one of claims 1-34 and a pharmaceutically acceptable carrier.

36. A method of treatment of osteoporosis in a patient in need of such treatment without causing substantial induction of hypotension, smooth muscle relaxation and cardiac inotropic and chronotropic action, said method comprising administering an osteoporotic effective amount of a PTH analogue according to any one of claims 1-34.

Fig. 1a

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Trp-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-Val-Ala-Leu-Gly-  
Ala-Ser-Ile-Ala-Tyr-Arg-Asp-Gly-Ser-Ser-Gln-Arg-Pro-  
Arg-Lys-Lys-Glu-Asp-Asn-Val-Leu-Val-Glu-Ser-His-Gln-  
Lys-Ser-Leu-Gly-Glu-Ala-Asp-Lys-Ala-Asp-Val-Asp-Val-  
Leu-Ile-Lys-Ala-Lys-Pro-Gln-CO<sub>2</sub>H

Fig. 1b

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Trp-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-Val-Ala-Leu-Gly-  
Ala-Ser-Ile-Ala-Tyr-Arg-Asp-Gly-Ser-Ser-Gln-Arg-Pro-  
Arg-Lys-Lys-Glu-Asp-Asn-Val-Leu-Val-Glu-Ser-His-Gln-  
Lys-Ser-Leu-Gly-Glu-Ala-Asp-Lys-Ala-Asp-Val-Asp-Val-  
Leu-Ile-Lys-Ala-Lys-Pro-Gln-CO<sub>2</sub>H

Fig. 2a

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Xaa-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2b

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Ala-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2c

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Arg-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2d

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Asn-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2e

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Asp-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2f

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Cys-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2g

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Gln-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2h

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Glu-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2i

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Gly-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2j

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-His-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2k

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Ile-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2l

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Lys-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2m

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Met-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2n

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Pro-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2o

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Ser-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 2p

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Thr-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3a

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Xaa-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3b

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Ala-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3c

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Arg-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3d

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Asp-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3e

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Asn-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3f

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Cys-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3g

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Gln-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3h

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Glu-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3i

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Gly-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3j

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-His-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3k

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Ile-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3l

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Lys-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3m

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Met-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3n

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Pro-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3o

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Ser-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 3p

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Thr-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-CO<sub>2</sub>H

Fig. 4

H<sub>2</sub>N-Ala-Val-Ser-Glu-Ile-Gln-Phe-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Ser-Ser-Met-Glu-Arg-Val-Glu-Xaa-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-Val-Ala-Leu-Gly-  
Ala-Ser-Ile-Ala-Tyr-Arg-Asp-Gly-Ser-Ser-Gln-Arg-Pro-  
Arg-Lys-Lys-Glu-Asp-Asn-Val-Leu-Val-Glu-Ser-His-Gln-  
Lys-Ser-Leu-Gly-Glu-Ala-Asp-Lys-Ala-Asp-Val-Asp-Val-  
Leu-Ile-Lys-Ala-Lys-Pro-Gln-CO<sub>2</sub>H

Fig. 5

H<sub>2</sub>N-Ser-Val-Ser-Glu-Ile-Gln-Leu-Met-His-Asn-Leu-Gly-  
Lys-His-Leu-Asn-Ser-Met-Glu-Arg-Val-Glu-Xaa-Leu-Arg-  
Lys-Lys-Leu-Gln-Asp-Val-His-Asn-Phe-Val-Ala-Leu-Gly-  
Ala-Ser-Ile-Ala-Tyr-Arg-Asp-Gly-Ser-Ser-Gln-Arg-Pro-  
Arg-Lys-Lys-Glu-Asp-Asn-Val-Leu-Val-Glu-Ser-His-Gln-  
Lys-Ser-Leu-Gly-Glu-Ala-Asp-Lys-Ala-Asp-Val-Asp-Val-  
Leu-Ile-Lys-Ala-Lys-Pro-Gln-CO<sub>2</sub>H

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# Effect of PTH analogues on D.B.P in SD

n=8

—+— PTH —○— 08117 —▲— 0899 —▽— 08100 —□— 08114

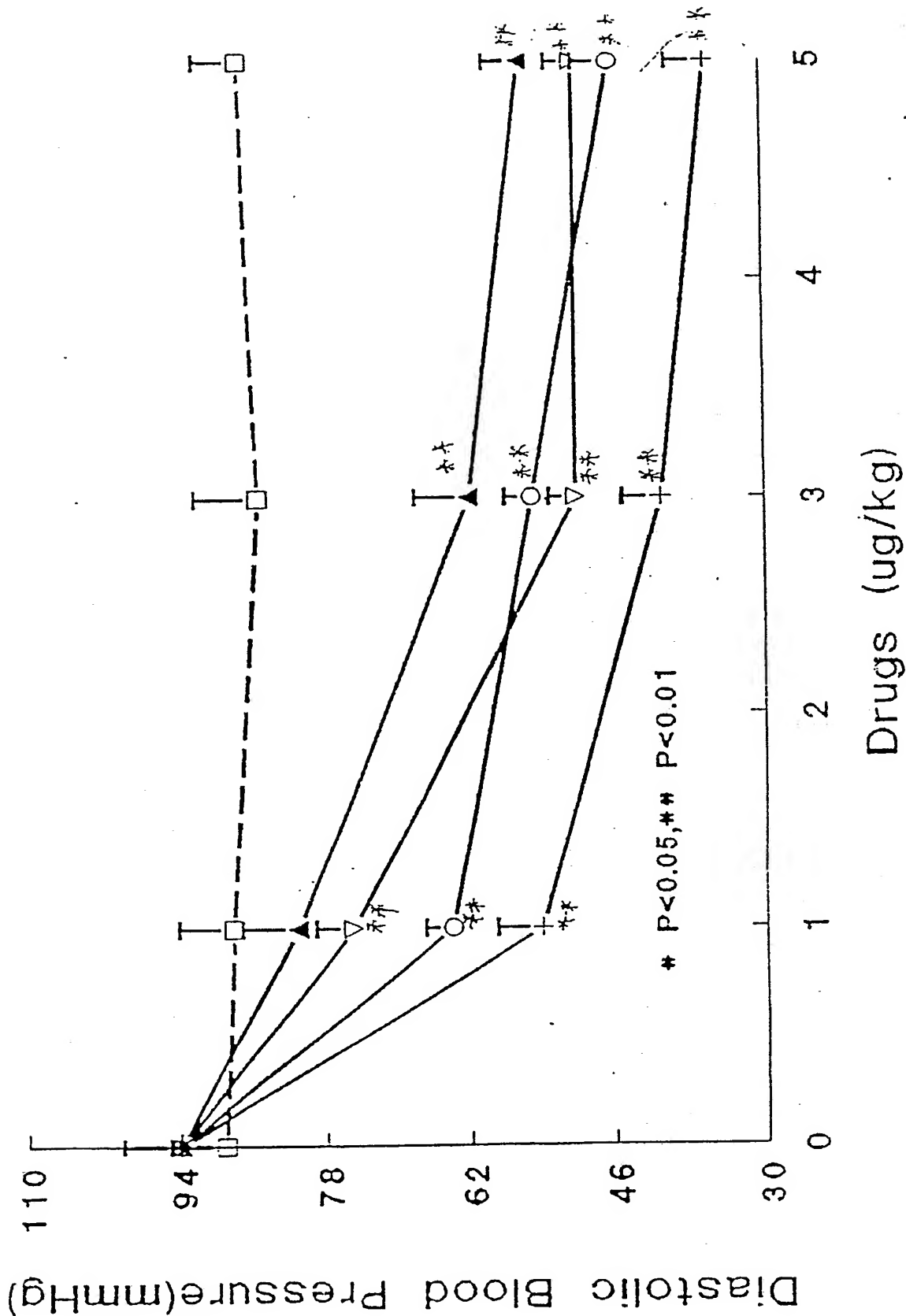


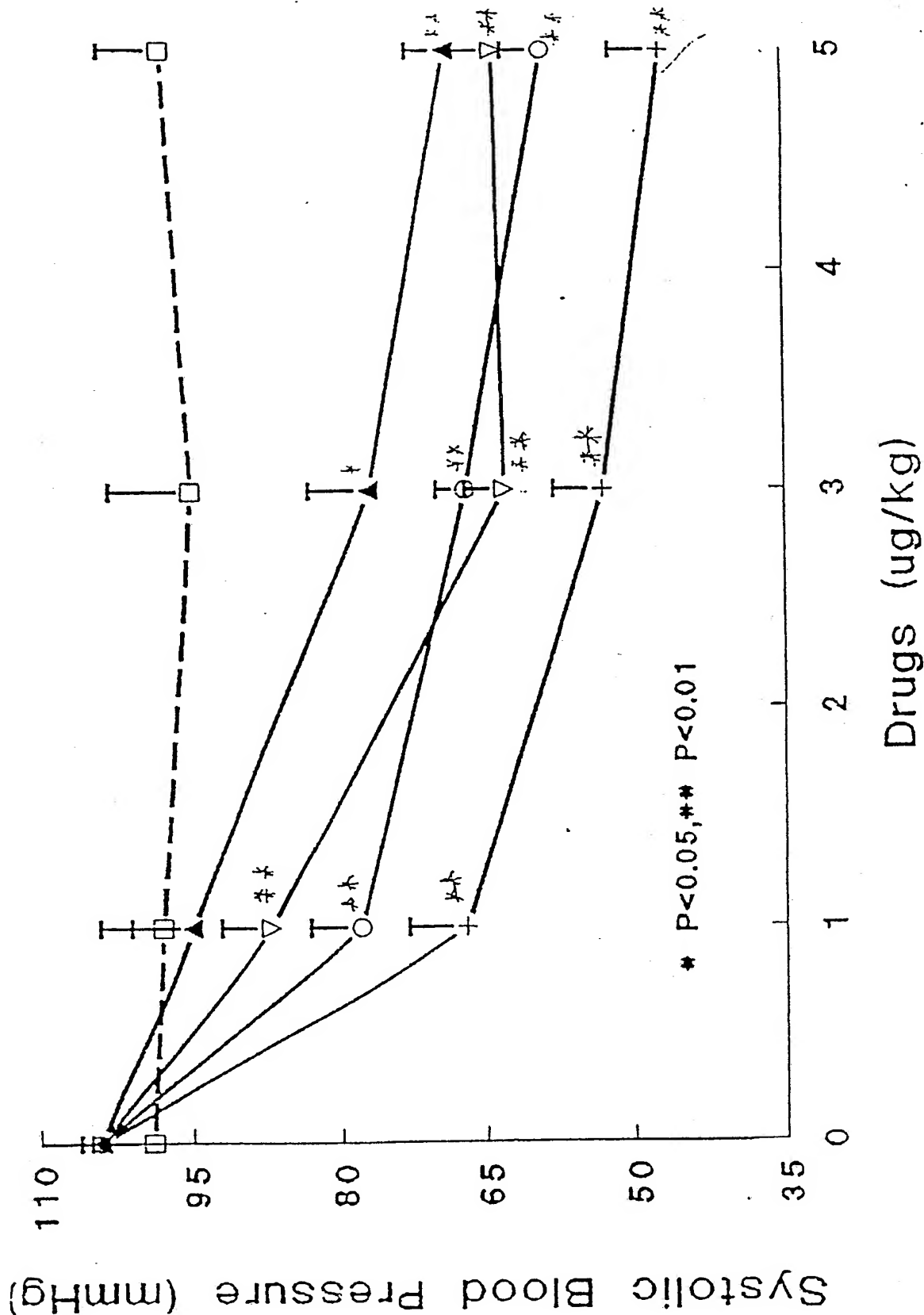
Fig. 6

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# Effect of PTH analogues on S.B.P. in SD

n=8

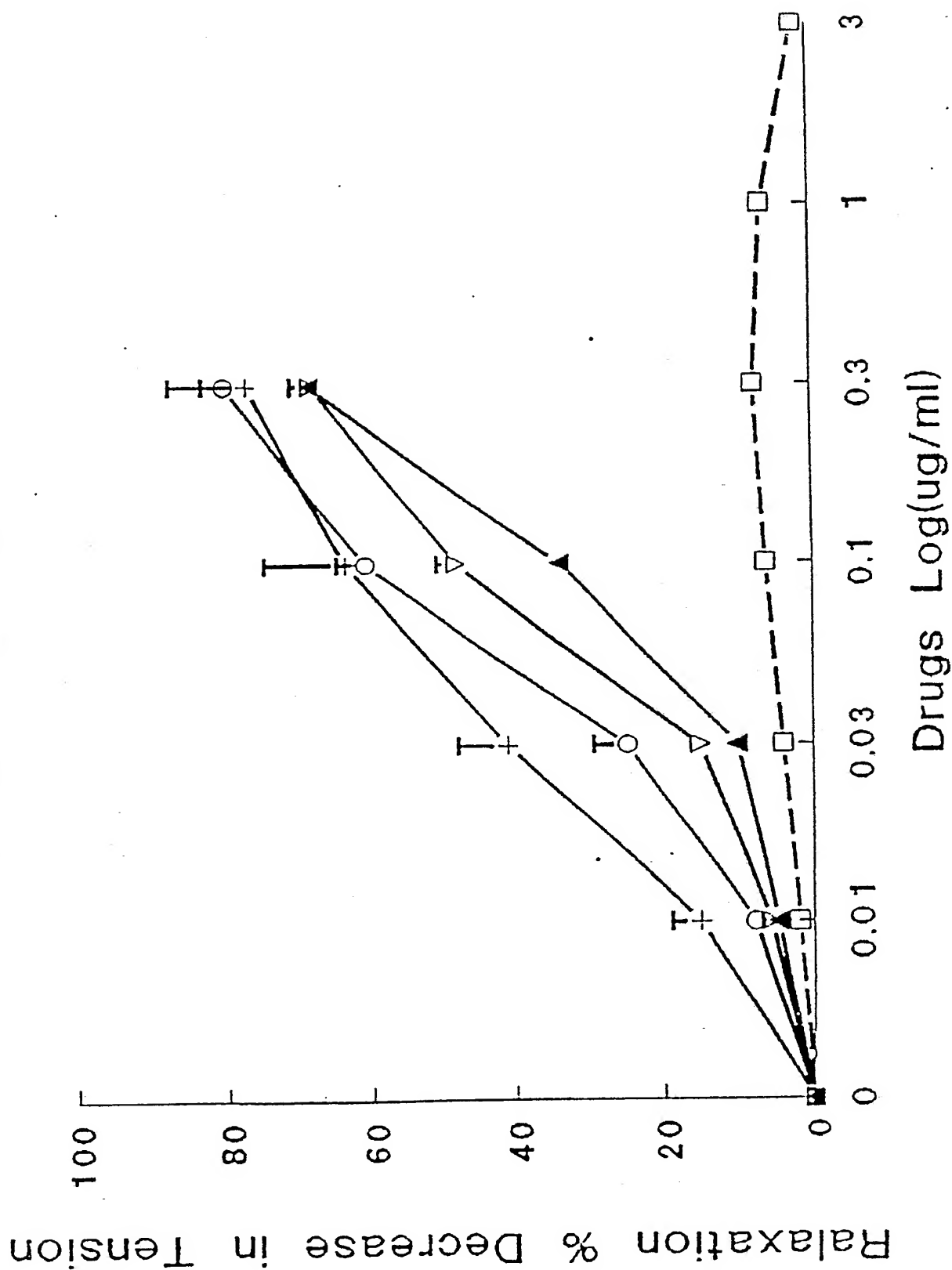
—+— PTH —○— cs117 —▲— cs99 —▽— cs100 —□— cs114



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Relaxation Effect of PTH Analogues on  
Rat Tail Artery Elicited by AVP (n=4)

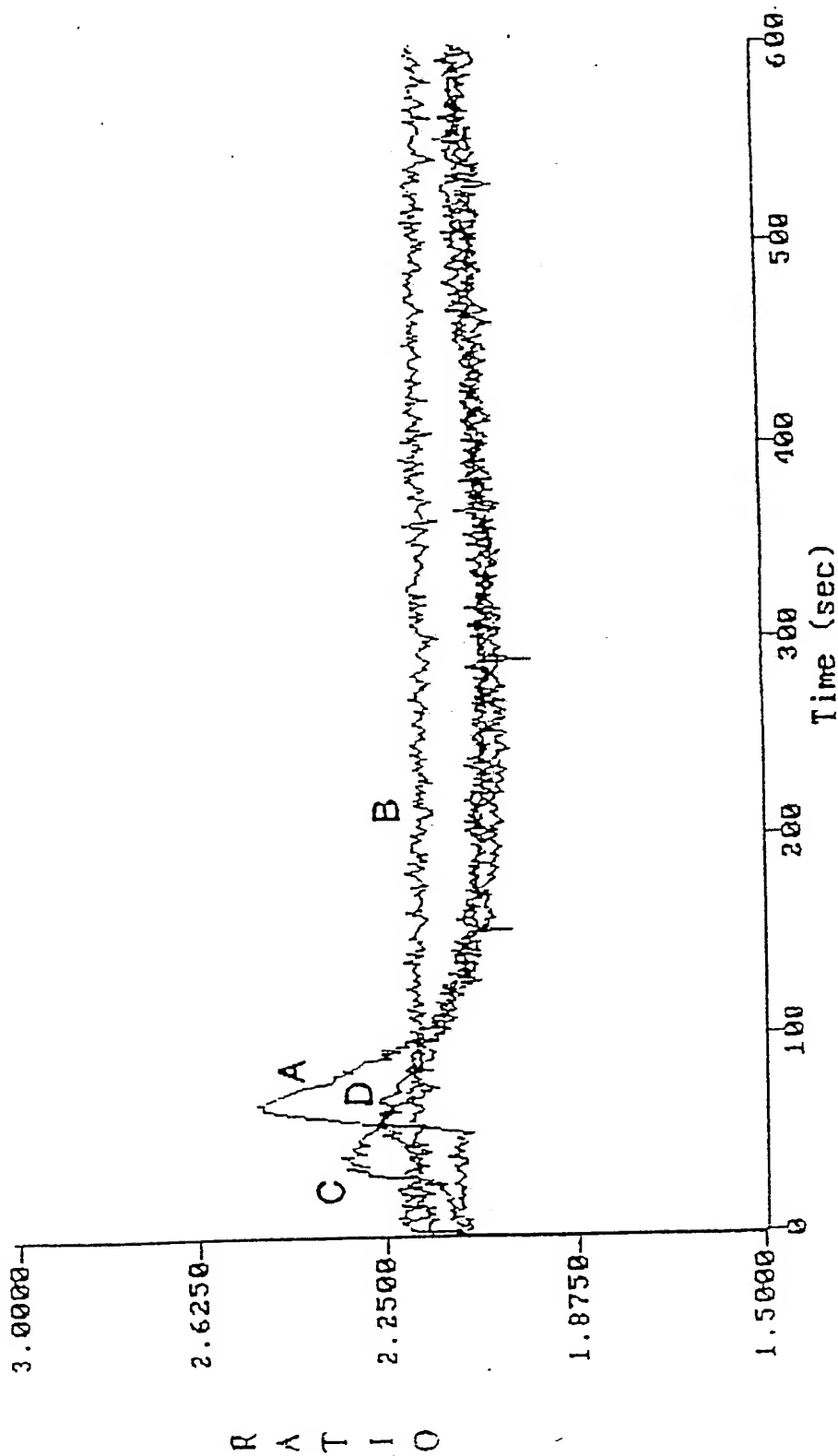
—+— PTH —○— 08117 —▲— 0899 —▽— 08100 —□— CS114



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Fig. 9

- A KCL 15 mM
- B 788 2\*10<sup>-5</sup>M
- C KCL 15 mM after 788 10m
- D KCL 15 mM after 788 20m



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Fig. 10b

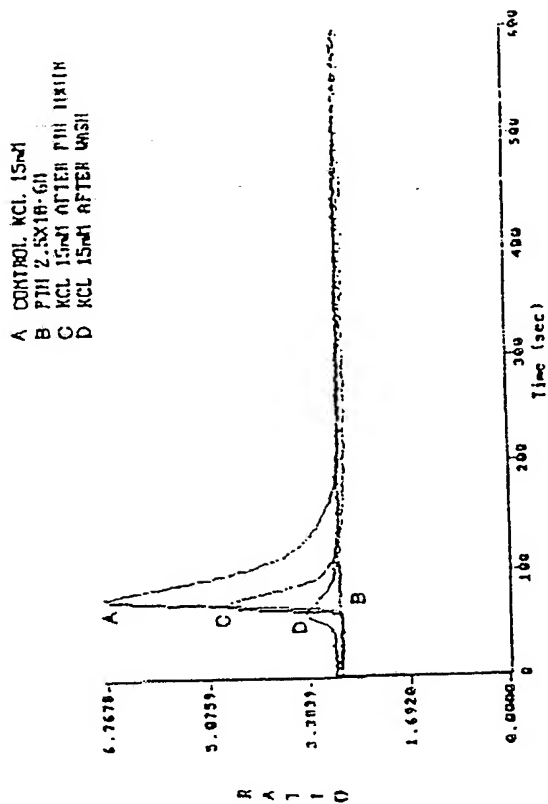


Fig 10a

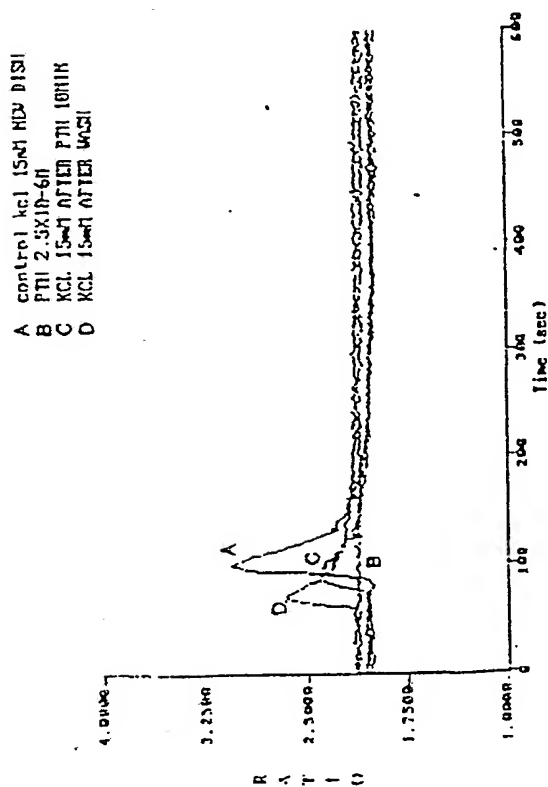


Fig 10d

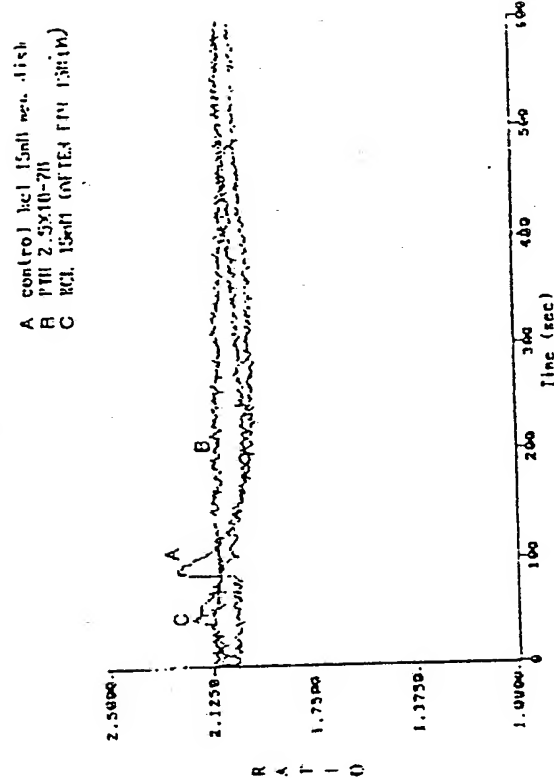
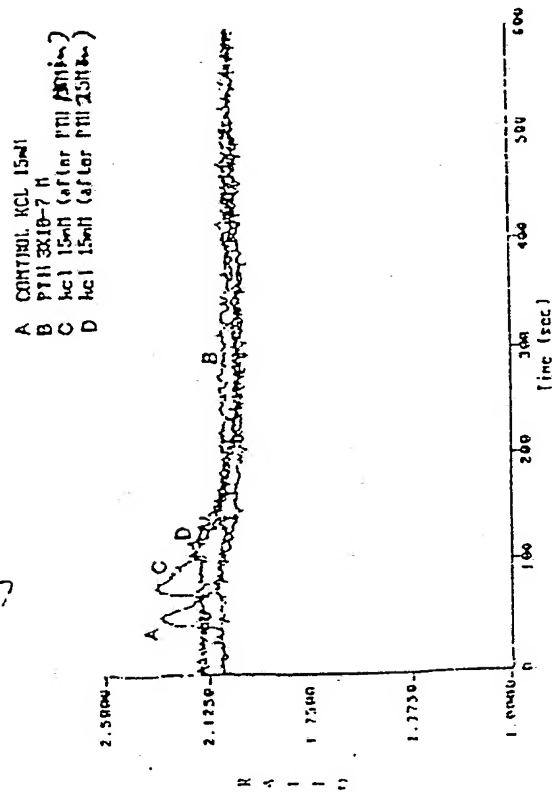


Fig 10c



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Fig 11a

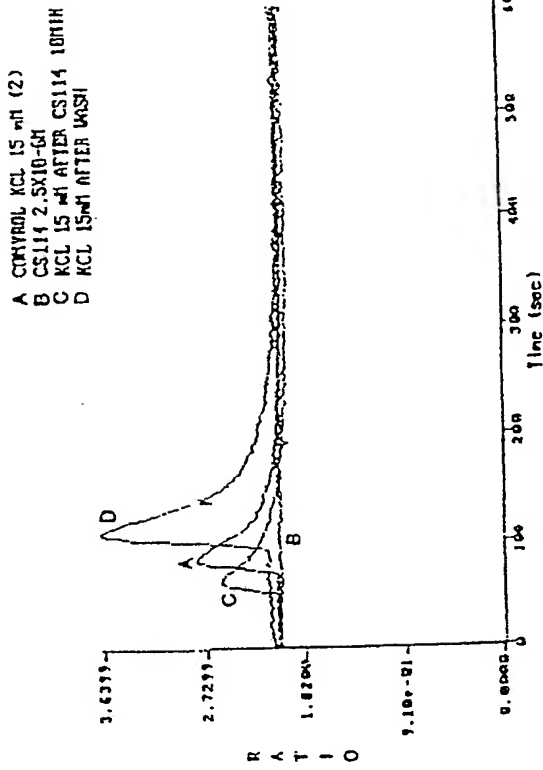


Fig 11c

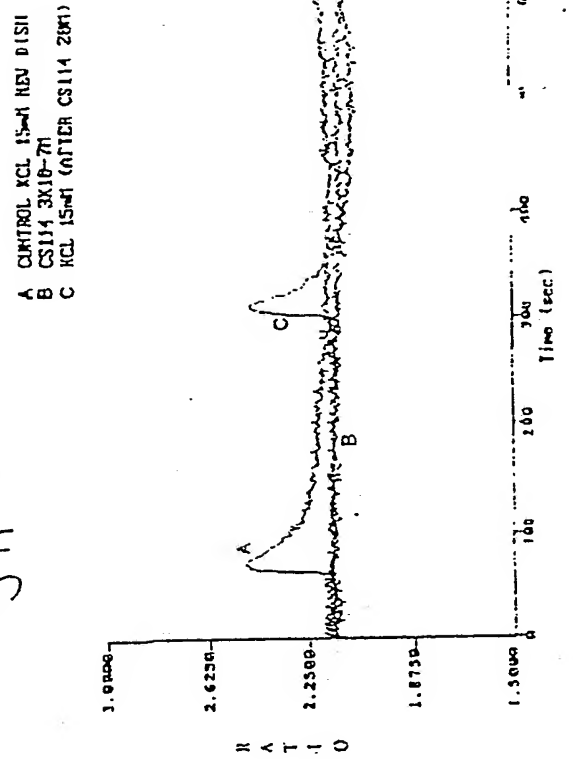
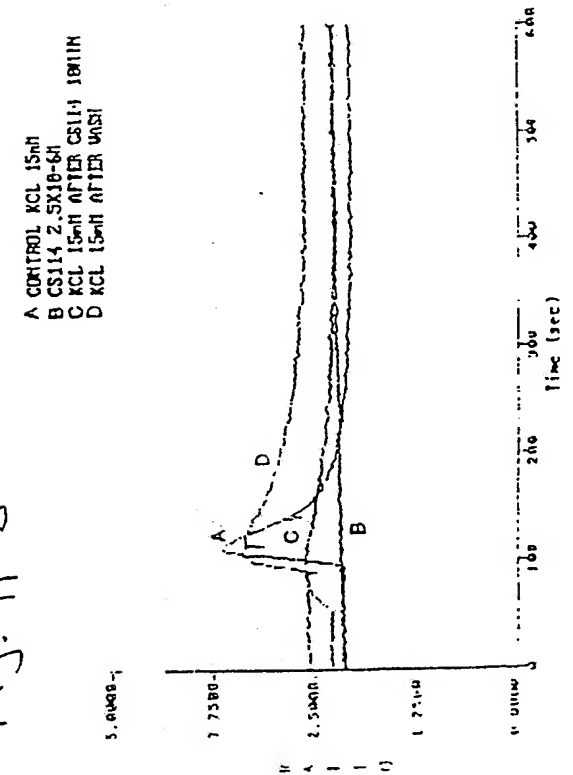


Fig. 11b

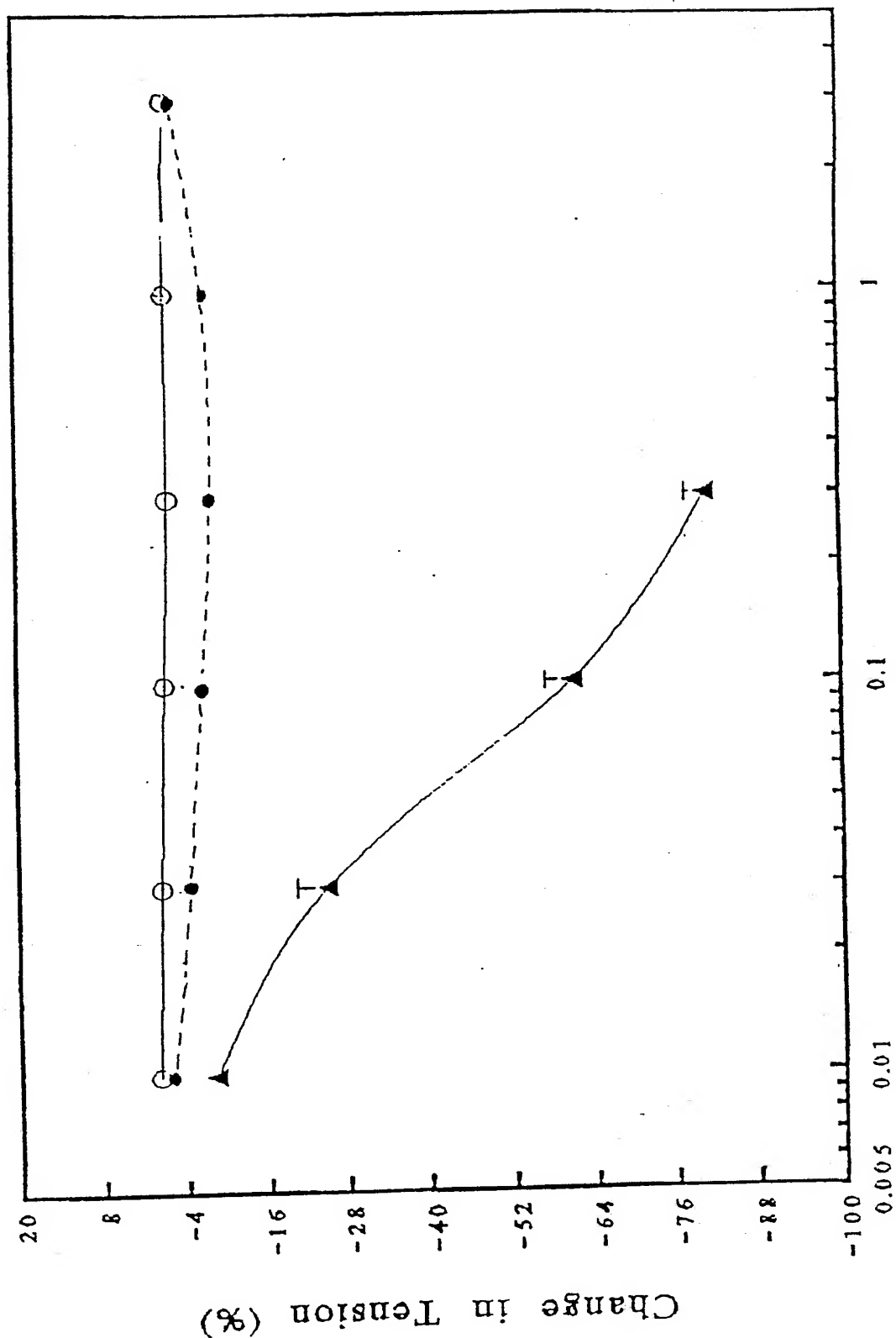


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Dose related relaxation curves produced by drug CS106,114,117,201 on SD rat tail artery helical strips precontracted with AVP ( $10^{-6}$ M).

Fig 12

● CS114 (n=4) 0.16±0.14mg  
▲ CS117 (n=4) 850±106mg  
○ CS201 (n=4) 793±41mg

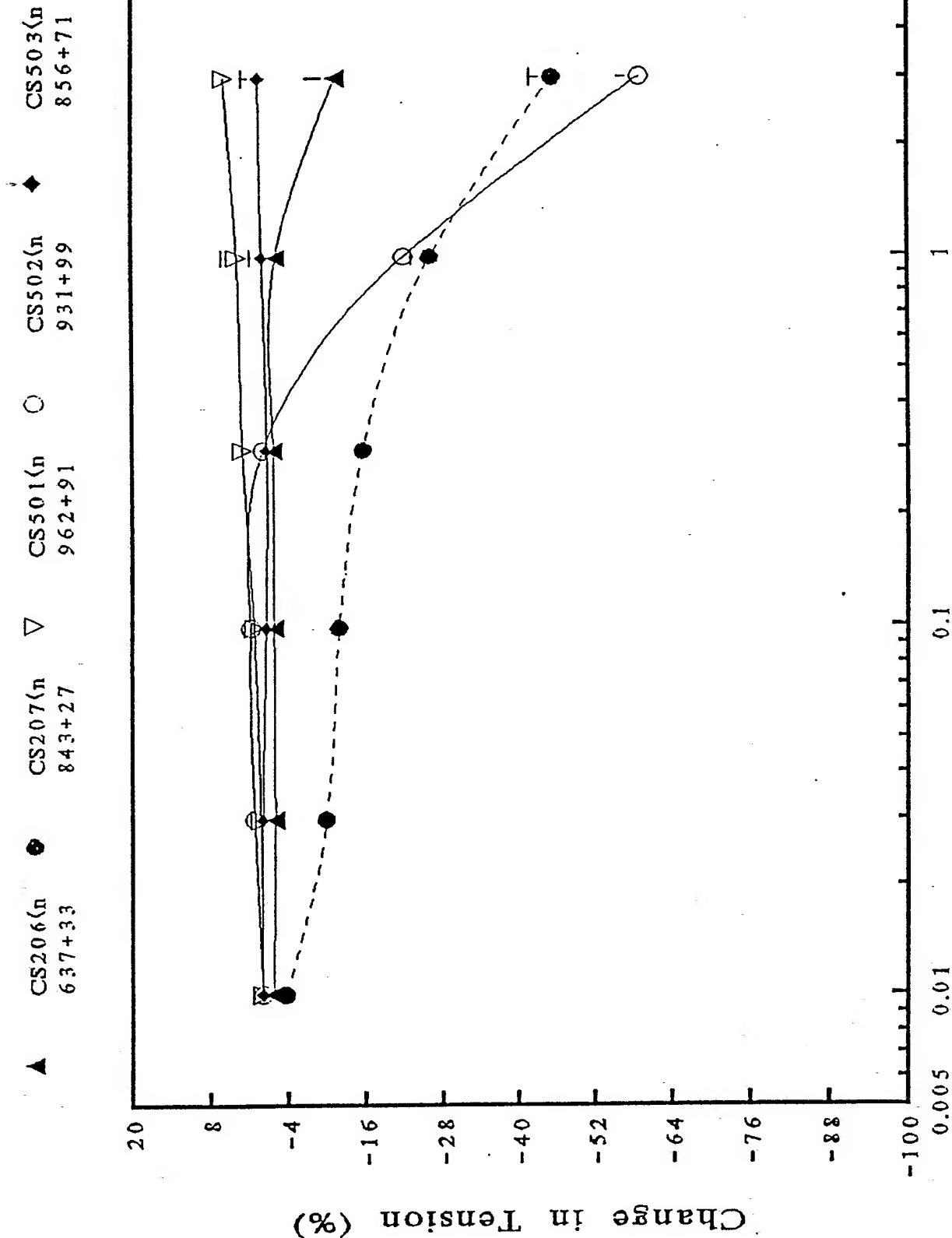


Drug CS106,114,117,201 (ug/ml)

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Fig. 13

Dose related relaxation curves produced by drug CS206,207,501,502,503 on SD rat tail artery helical strips precontracted with AVP ( $10^{-8}$ M).



Drug CS206,207,501,502,503 (ug/ml)

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Fig. 14

Dose related relaxation curves produced by drug CS117,201,501,502 and 503 on SD rat tail artery helical strips precontracted with KCL (60mM)

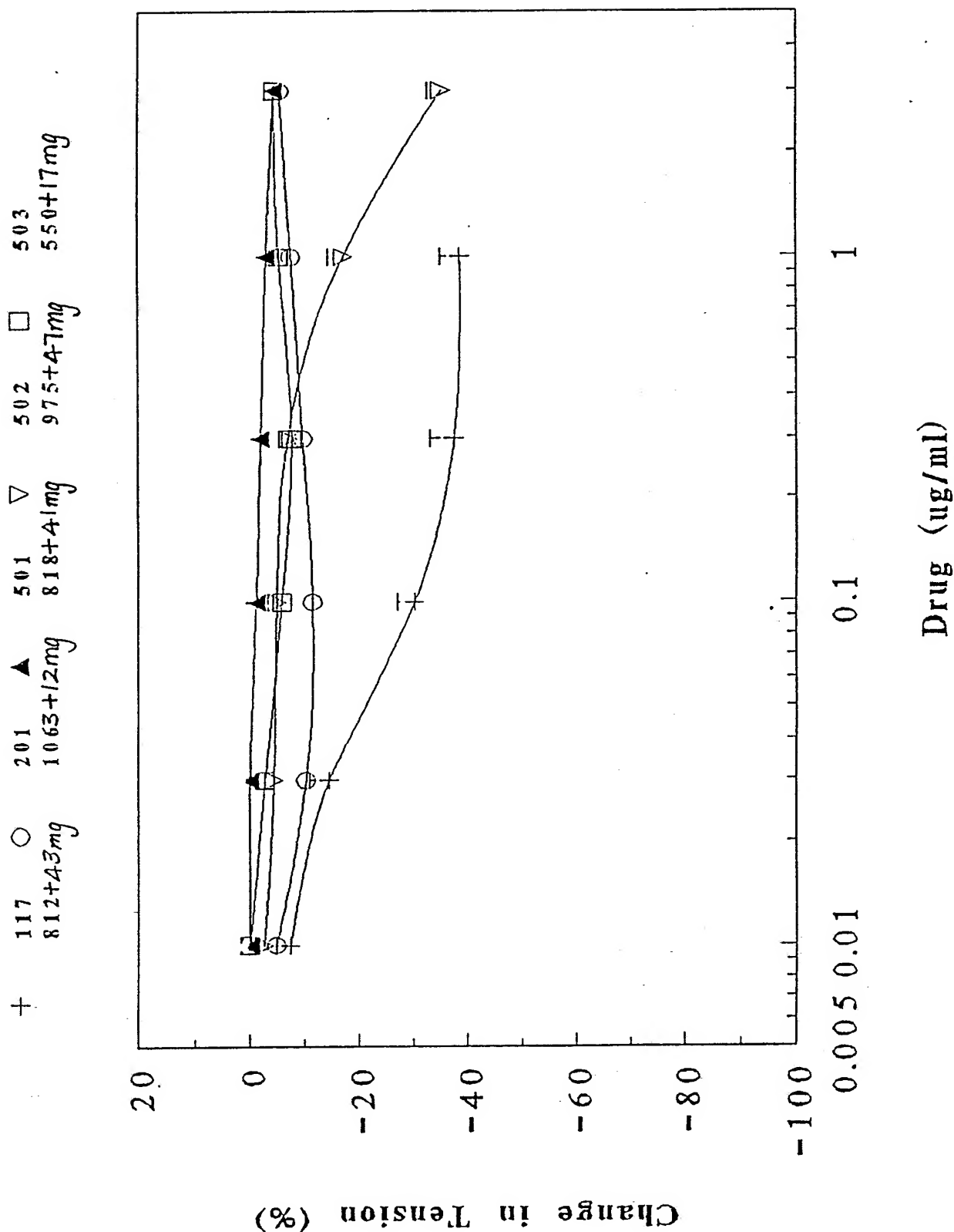
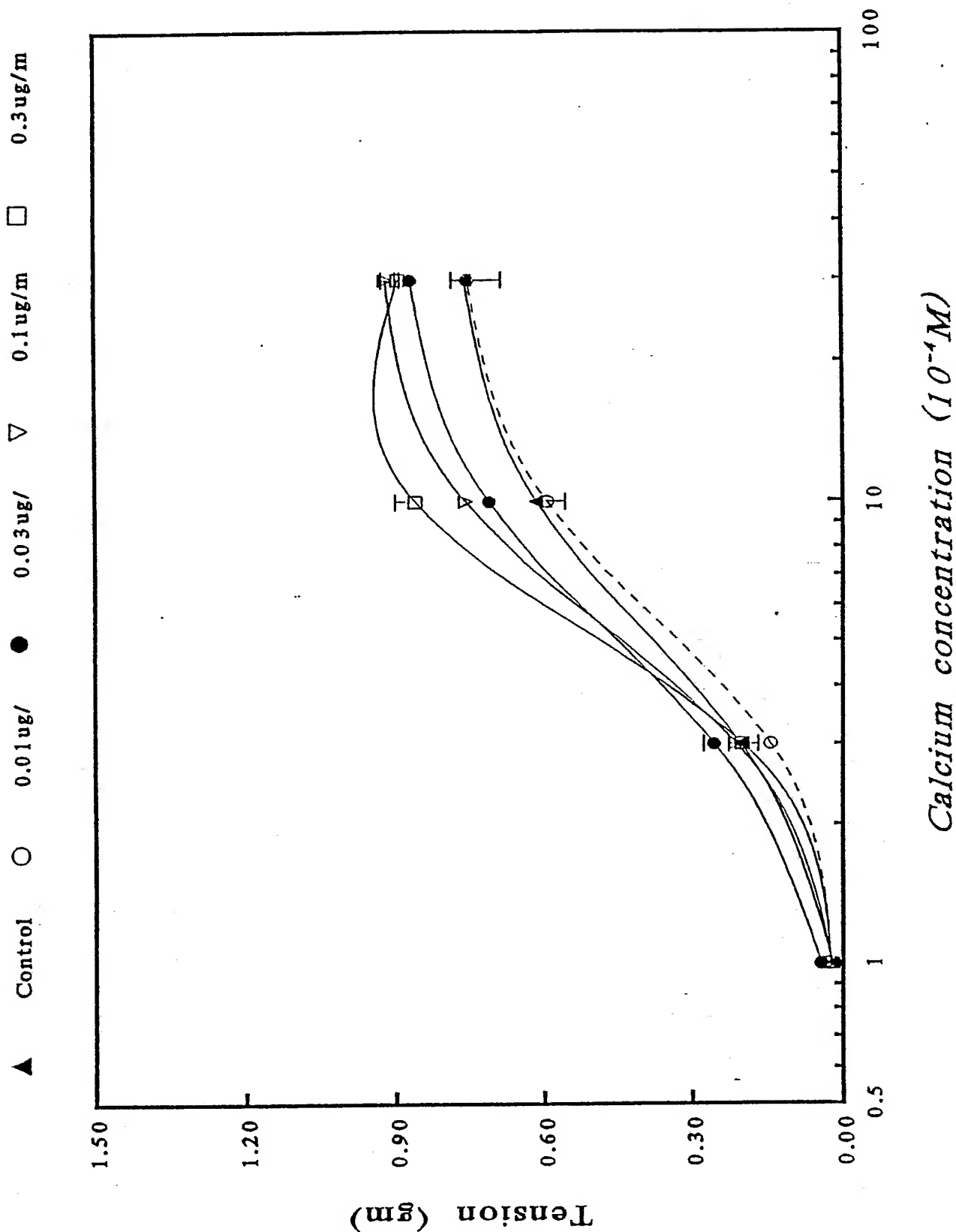


Fig. 15

Dose related inhibition of extracellular calcium influx by drug CS114  
The rat tail artery helical strips were precontracted with NE(10<sup>-7</sup>)M

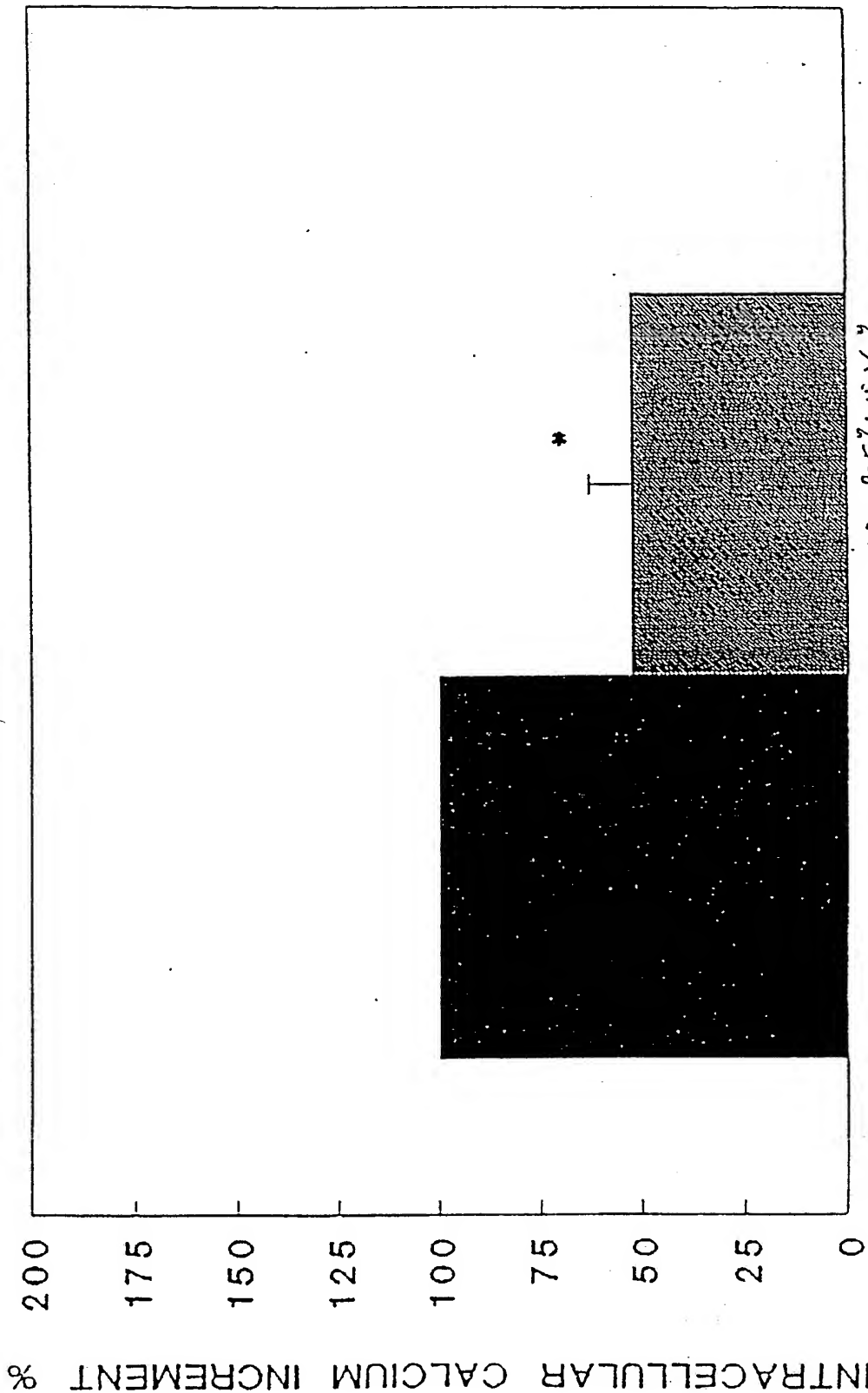


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# EFFECT OF CS114 (B) ON INTRACELLULAR CALCIUM INCREMENT INDUCED BY KCL IN UMR

CS114B 2.5uM  
KCL 30mM

CONTROL  
KCL 30mM



48.18 ± 15.16%

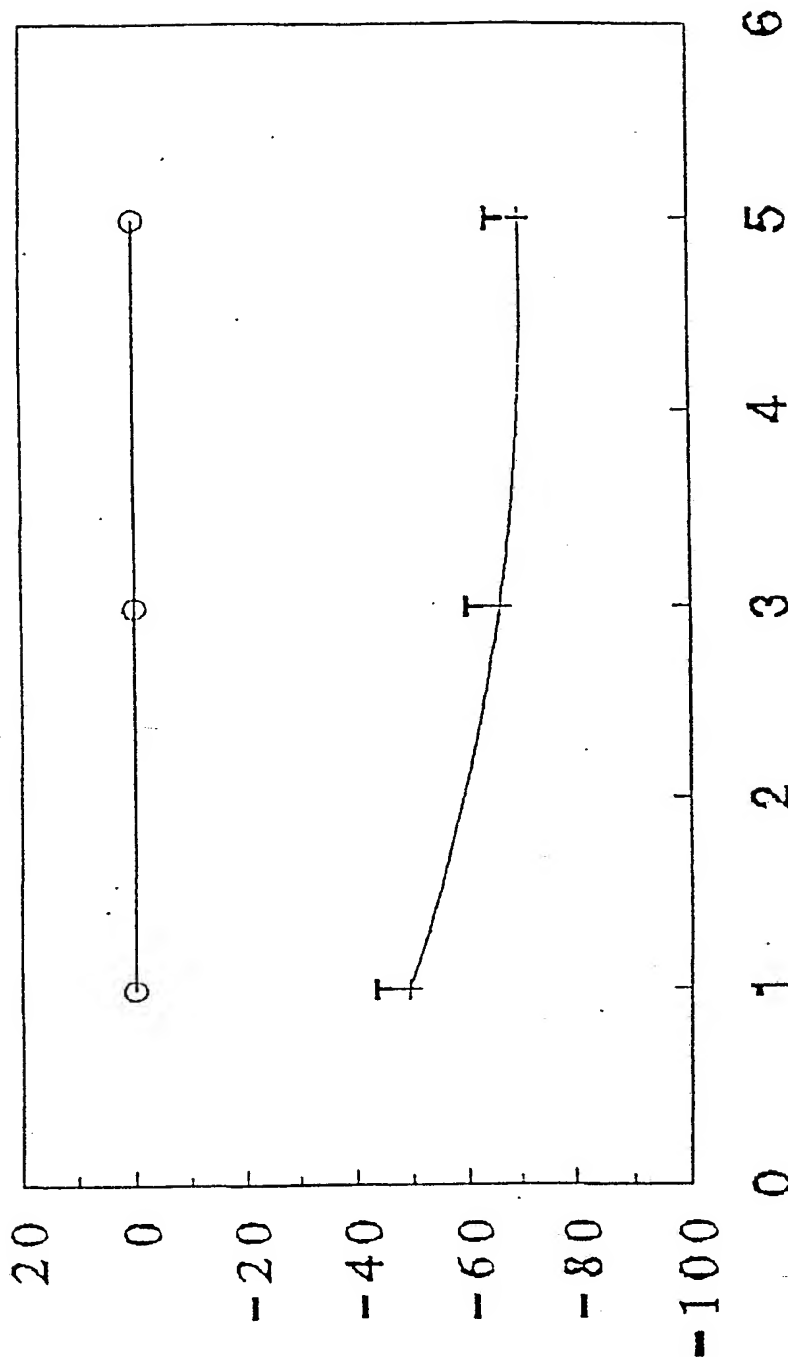
\* P<0.05

Fig. 16

# Effect of CS205 on Blood Pressure of Anesthetized SD Rats (n=6)

+ bPTH(1-34)      ○ CS205  
138±14mmHg      138±14mmHg

Blood Pressure Change (mmHg)



Drug (ug/kg)

Fig. 17

Fig. 18

Dose related relaxation curves produced by drug CS205 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (10<sup>-6</sup>M) or AVP (10<sup>-1</sup>M)

+	KCL (n=4)	○	NE (n=4)	▲	AVP (n=4)
	931±73mg		136±55mg		981±80mg

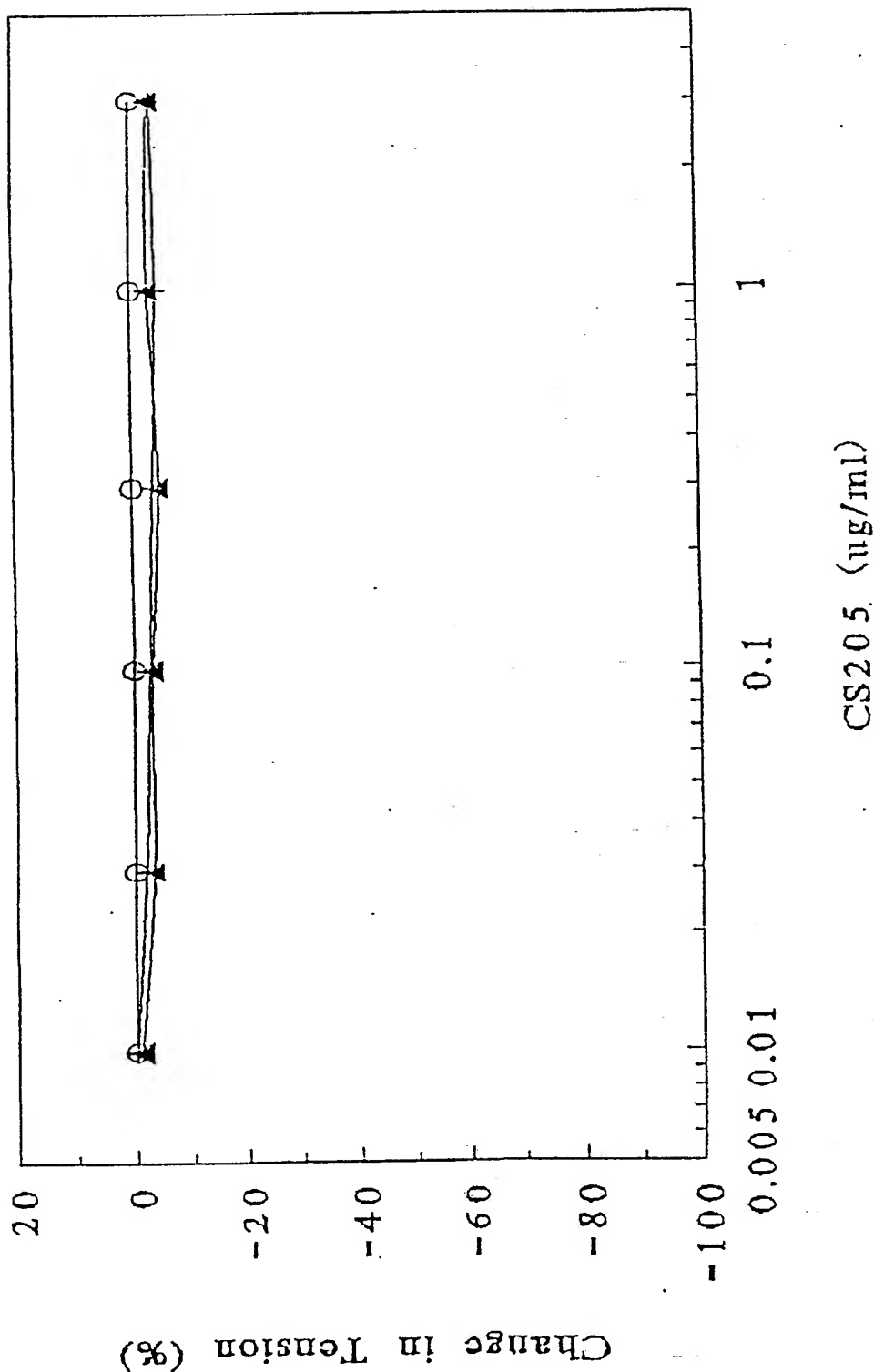


Fig-19

# Effect of CS201 on Blood Pressure of Anesthetized SD Rats (n=6)

+ bPTH(1-34) CS201  
125±11mmHg 125±10mmHg

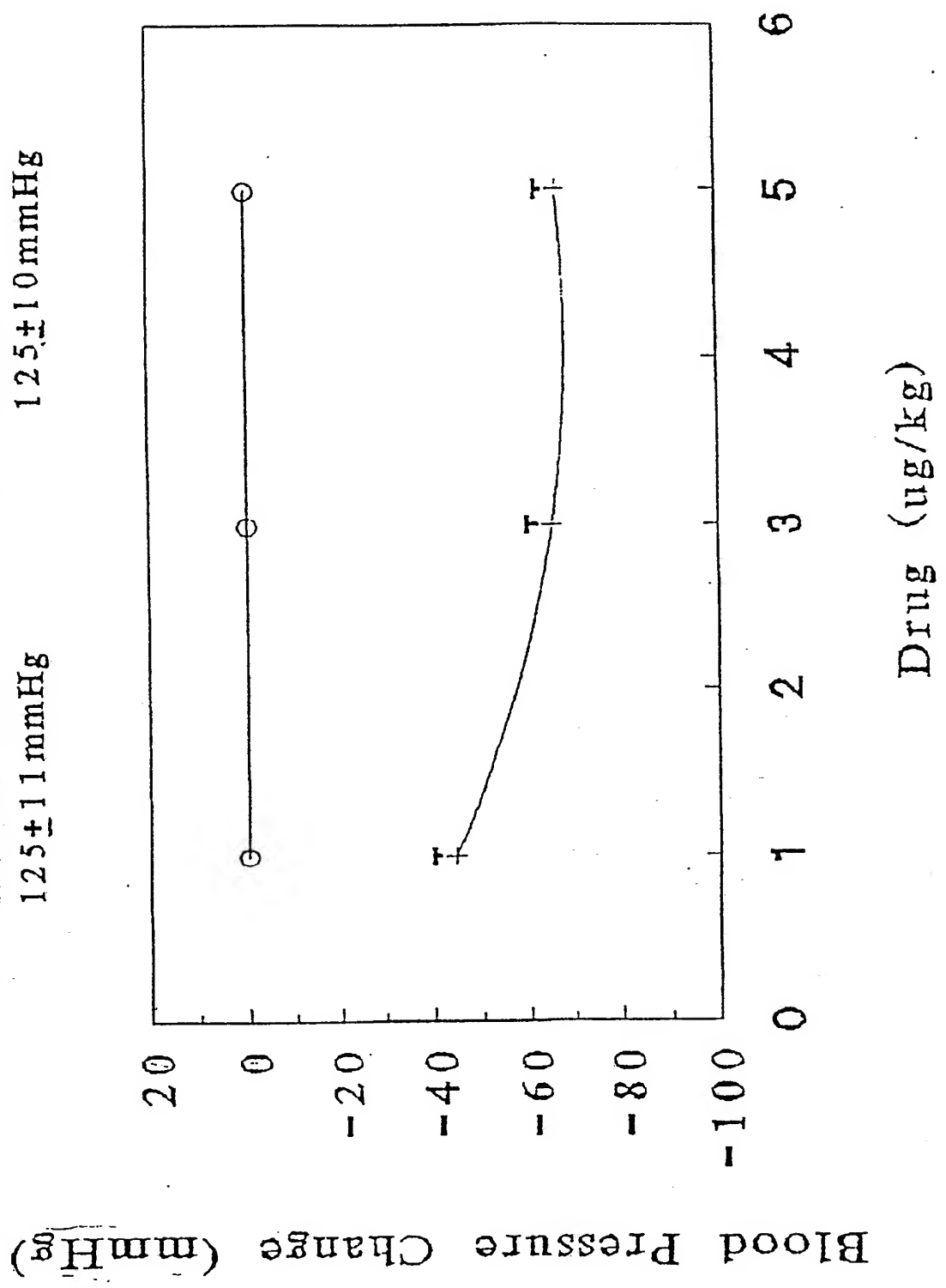


Fig. 20

Dose related relaxation curves produced by drug CS201 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (3x10<sup>-7</sup>M) or AVP (10<sup>-7</sup>M)

+ KCL (n=4) 1063±120mg      ○ NE (n=4) 1075±92mg      ▲ AVP (n=4) 793±41mg

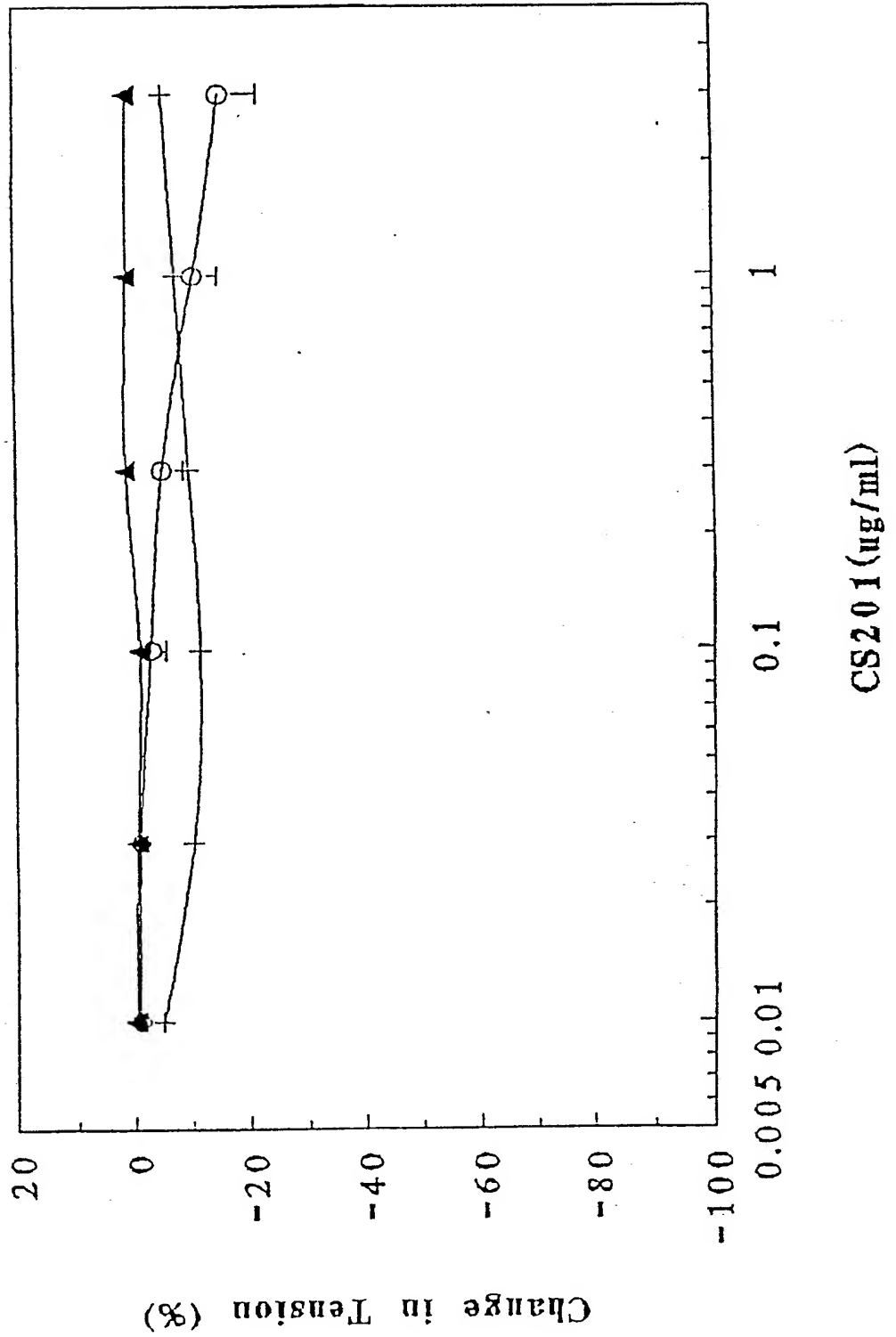
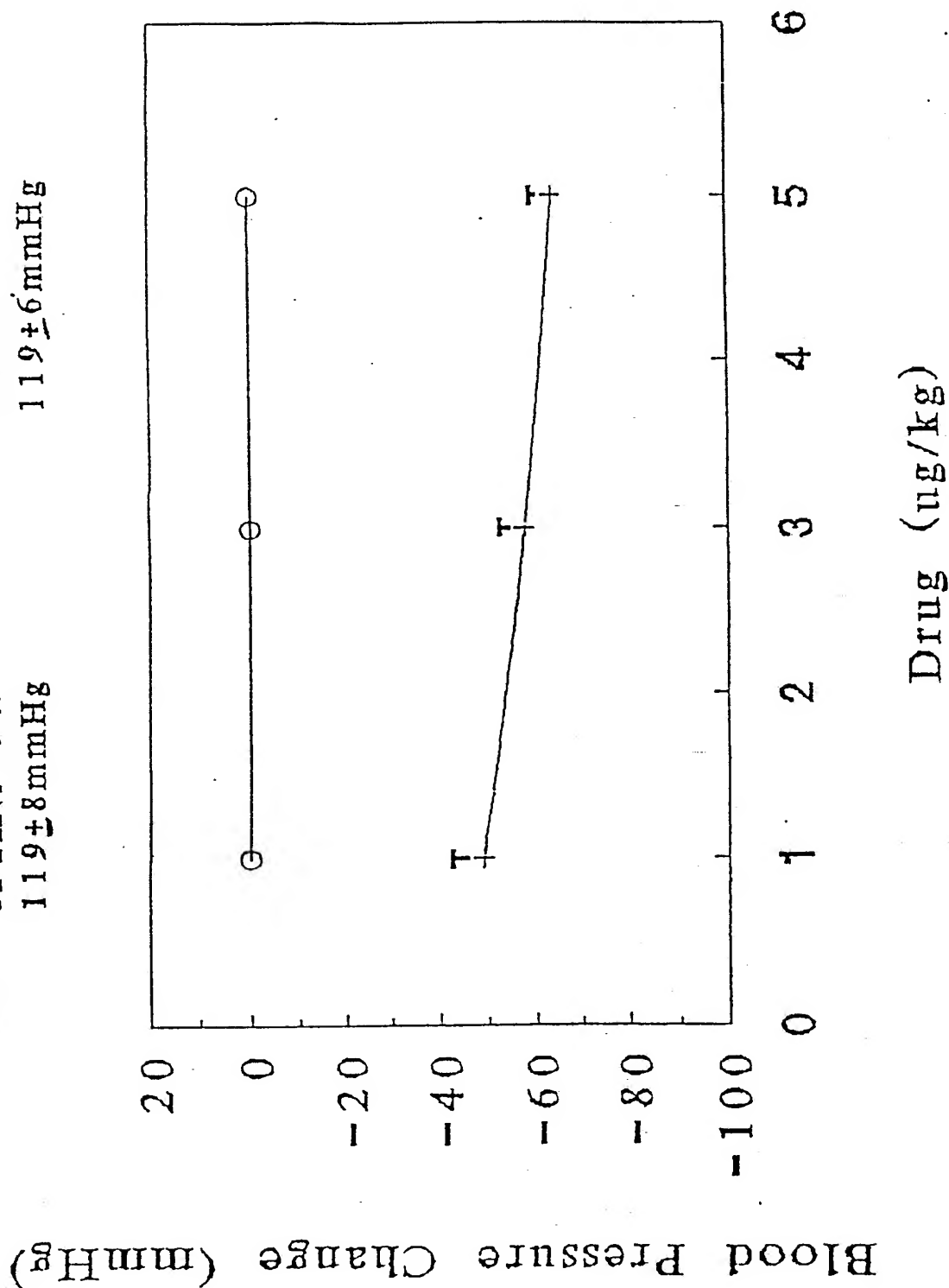


Fig 21

# Effect of CS503 on Blood Pressure of Anesthetized SD Rats (n=8)

+ bPTH(1-34)      ○ CS503  
119±8mmHg      119±6mmHg

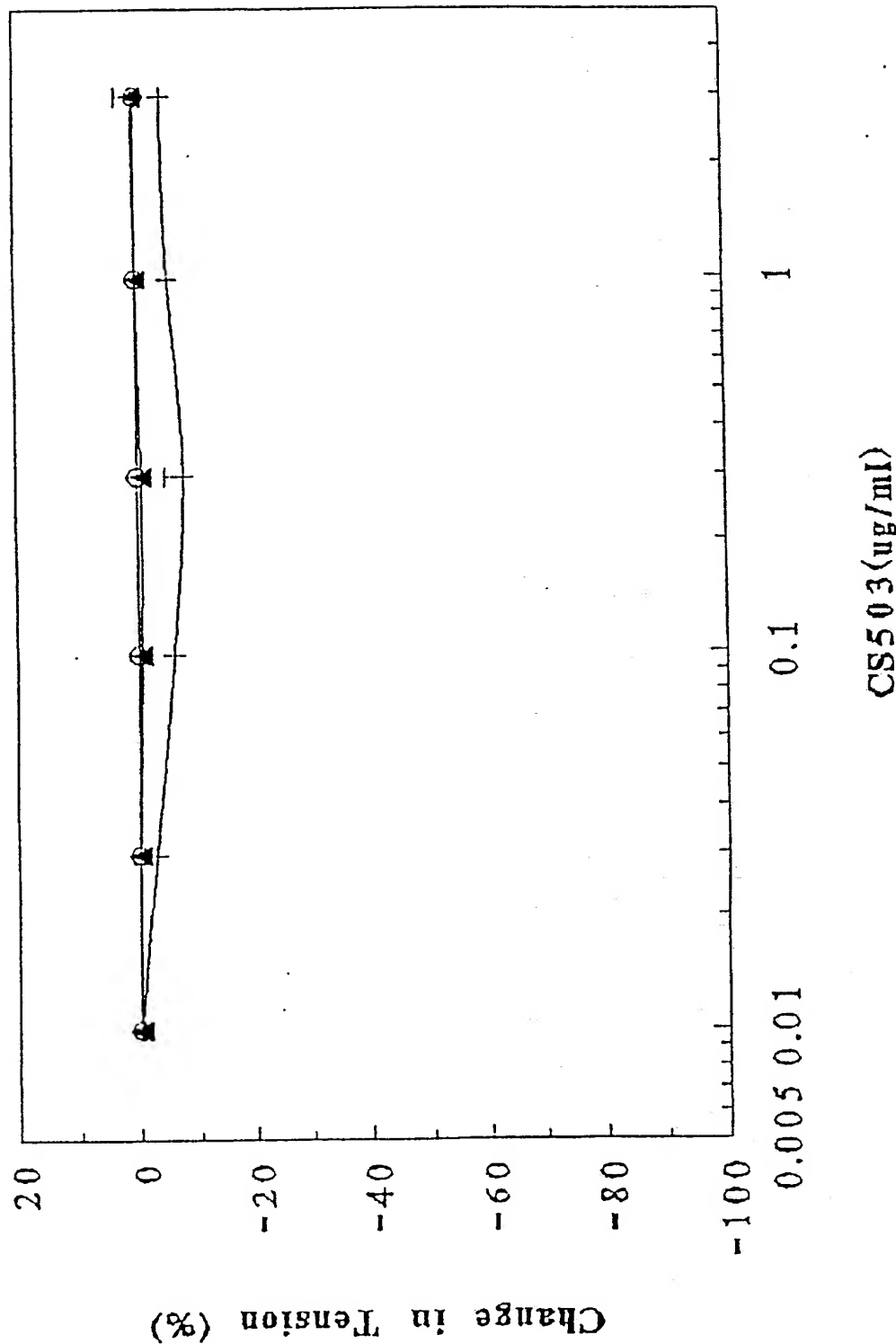


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Fig 22

Dose related relaxation curves produced by drug CS503 on SD rat tail artery helical strips precontracted with KCL ( $60\text{mM}$ ), NE ( $10^{-6}\text{M}$ ) or AVP ( $10^{-7}\text{M}$ )

+	KCL (n=4)	○	NE (n=4)	▲	AVP (n=4)
	550±17mg		856±31mg		856±71mg

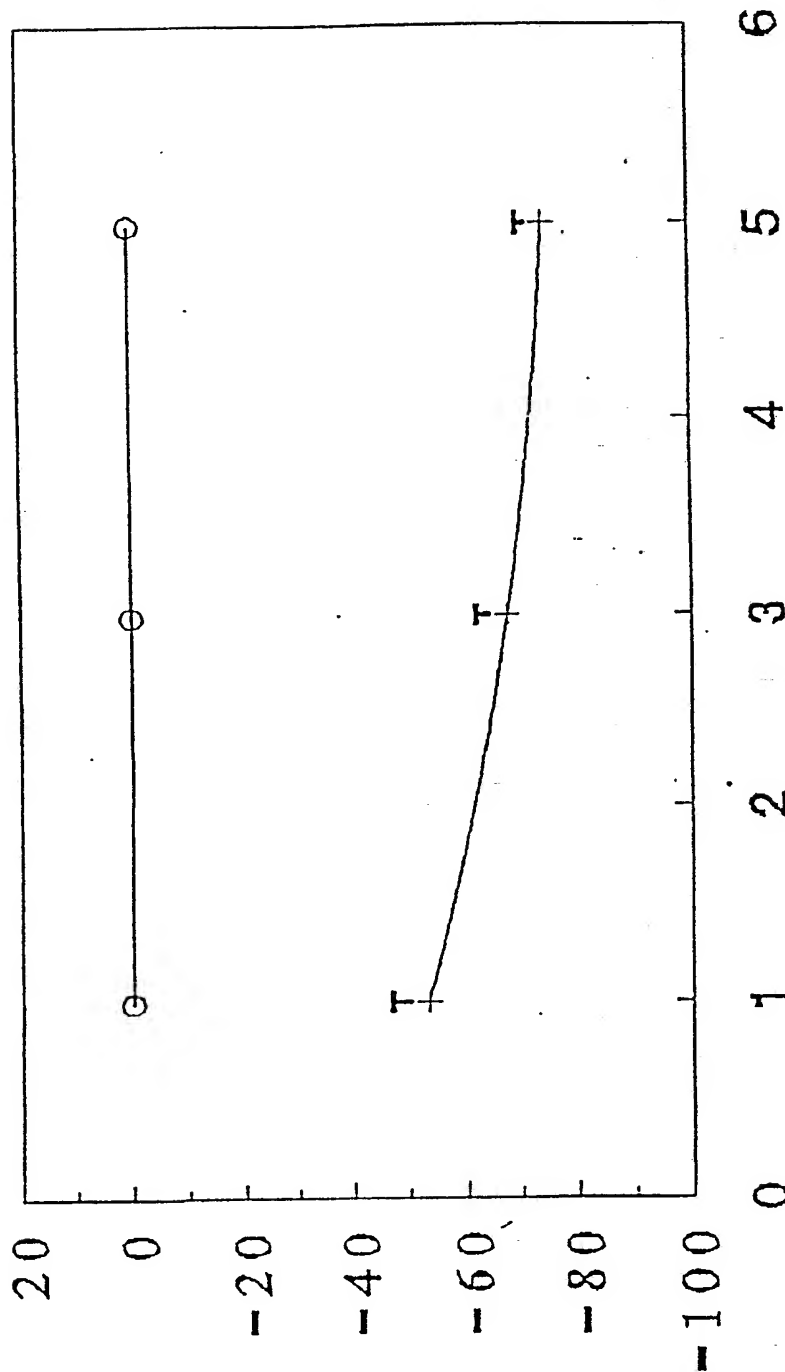


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# Effect of CS502 on Blood Pressure of Anesthetized SD Rats (n=8)

+ bPTH(1-34)      ○ CS502  
139±6mmHg      139±6mmHg

Blood Pressure Change (mmHg)



Drug (ug/kg)

Fig-23

Fig. 24

Dose related relaxation curves produced by drug CS502 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (10<sup>-6</sup>M) or AVP (10<sup>-6</sup>M)

+ KCL (n=4) 975±47mg      ○ NE (n=4) 1400±73mg      ▲ AVP (n=4) 931±99mg

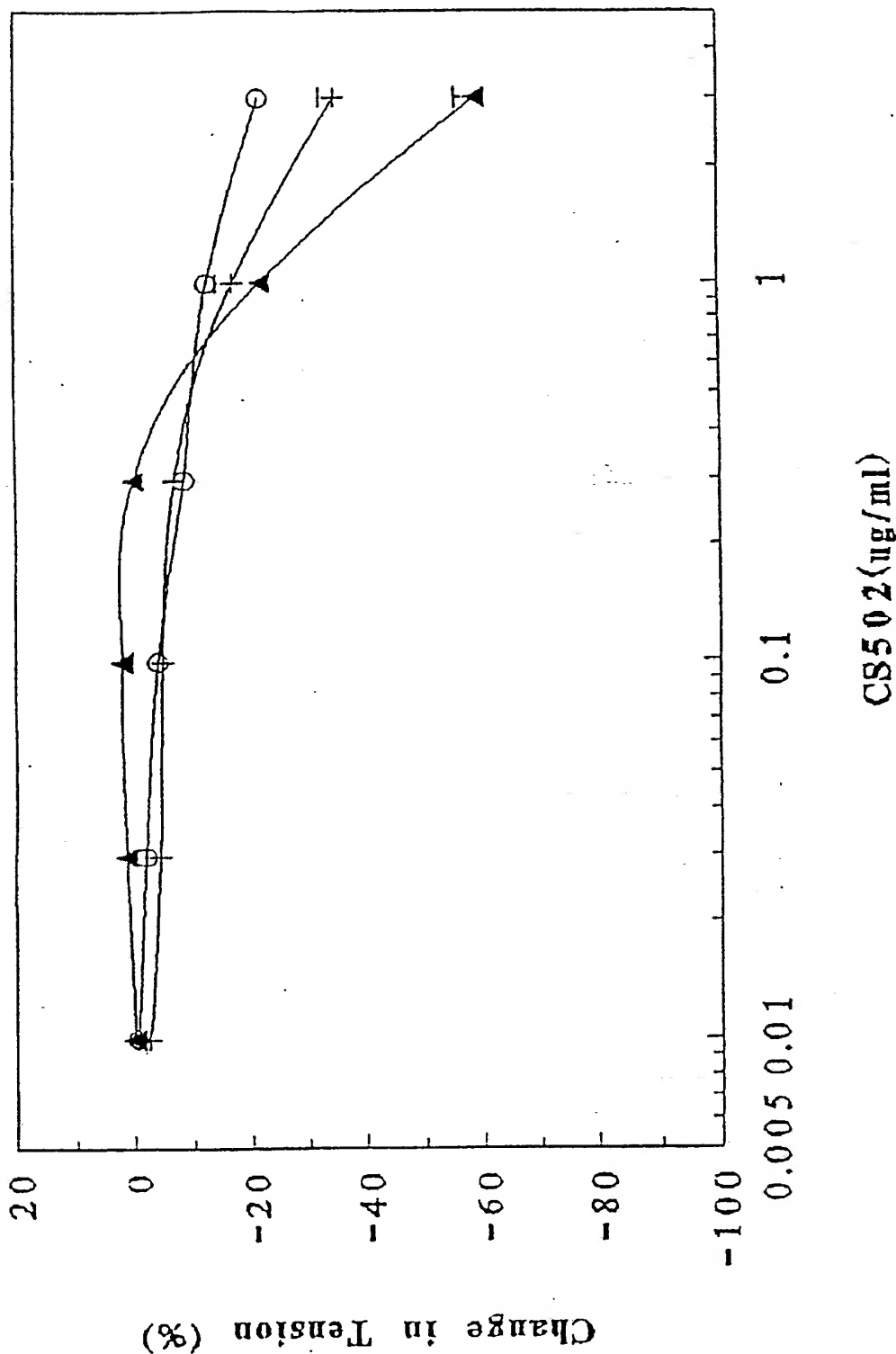
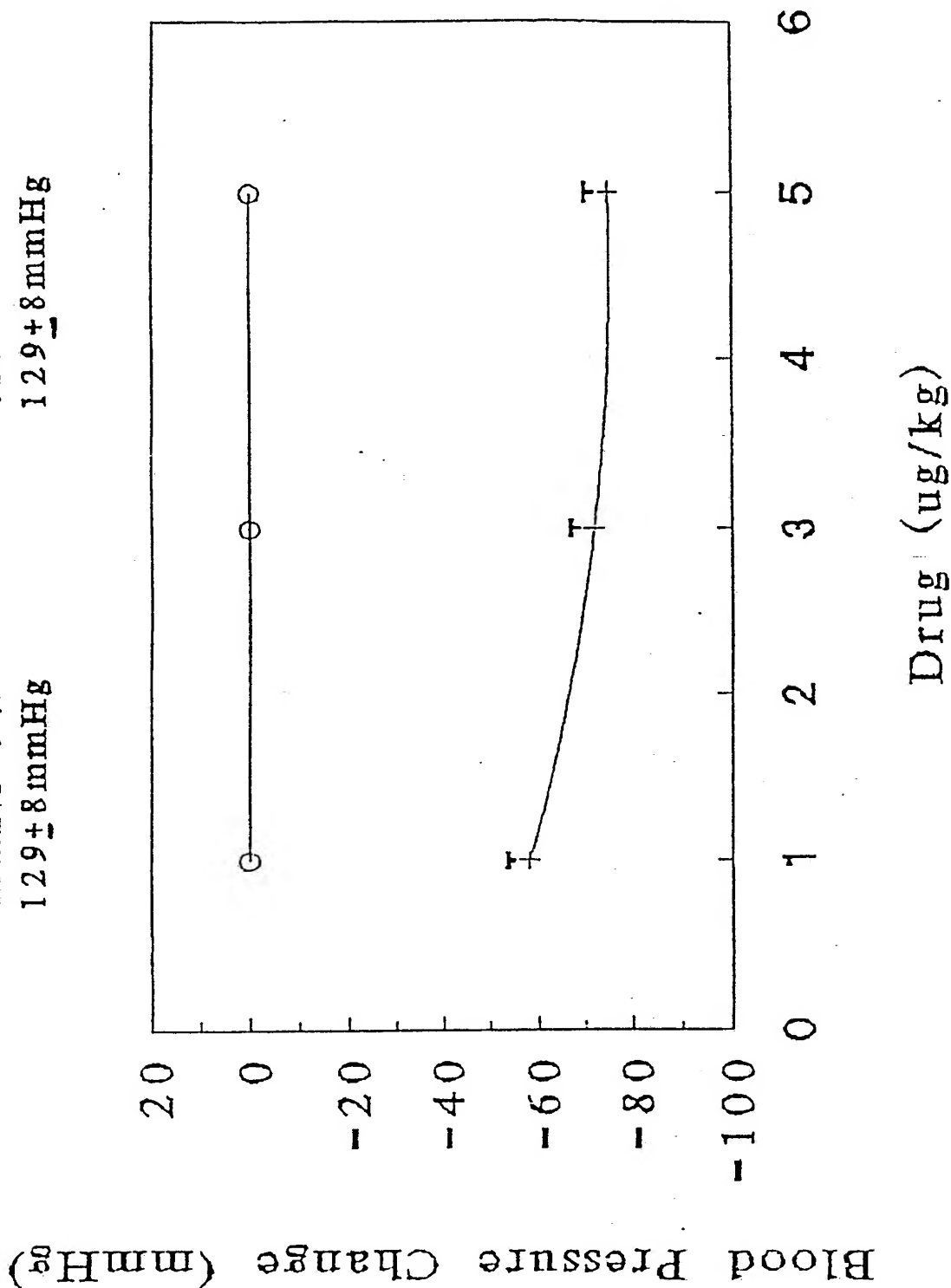


Fig 25

# Effect of CS501 on Blood Pressure of Anesthetized SD Rats (n=8)

+ bPTH(1-34)    ○ CS501  
129±8mmHg    129±8mmHg



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Fig 26

Dose related relaxation curves produced by drug CS501 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (10<sup>-6</sup>M) or AVP (10<sup>-6</sup>M)

+ KCL (n=4) 818±41mg      ○ NE (n=4) 1043±73mg      ▲ AVP (n=4) 962±91mg

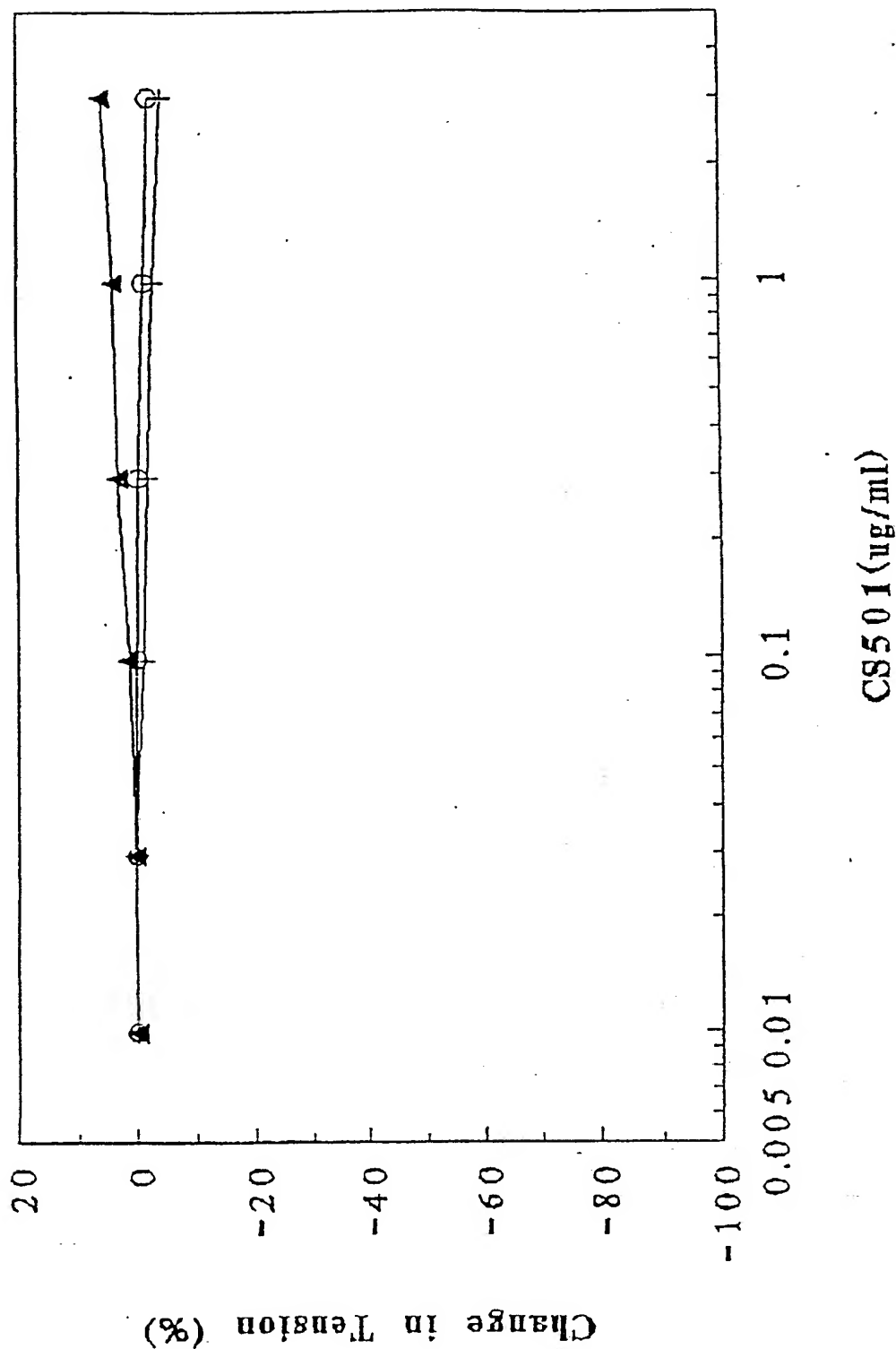


Fig. 27

# Effect of CS207 on Blood Pressure of Anesthetized SD Rats (n=6)

+ bPTH(1-34)      ○ CS207  
143±6mmHg      134±7mmHg

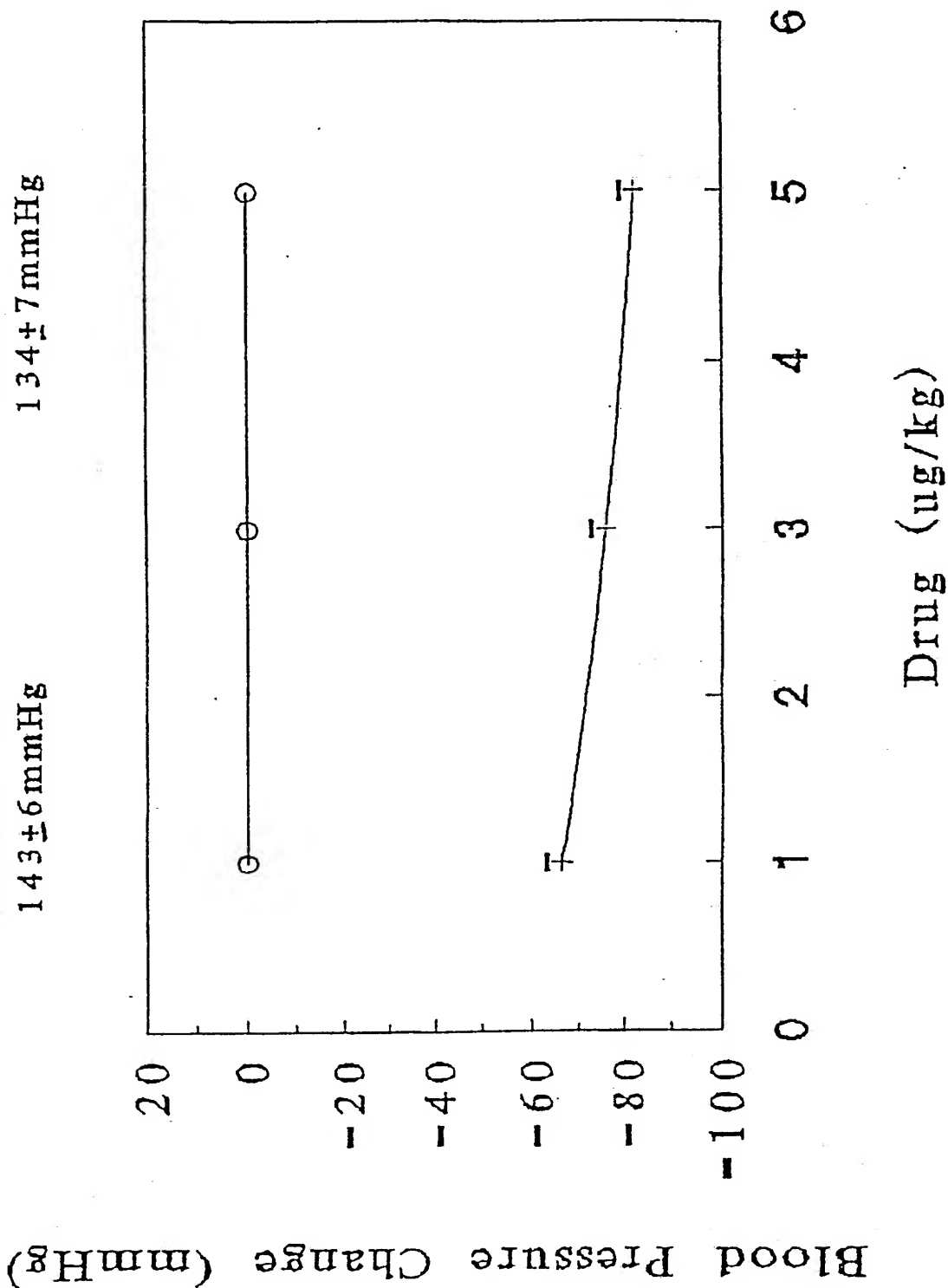


Fig 28

Dose related relaxation curves procuced by drug CS207 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (10<sup>-6</sup>M) or AVP (10<sup>-6</sup>M)

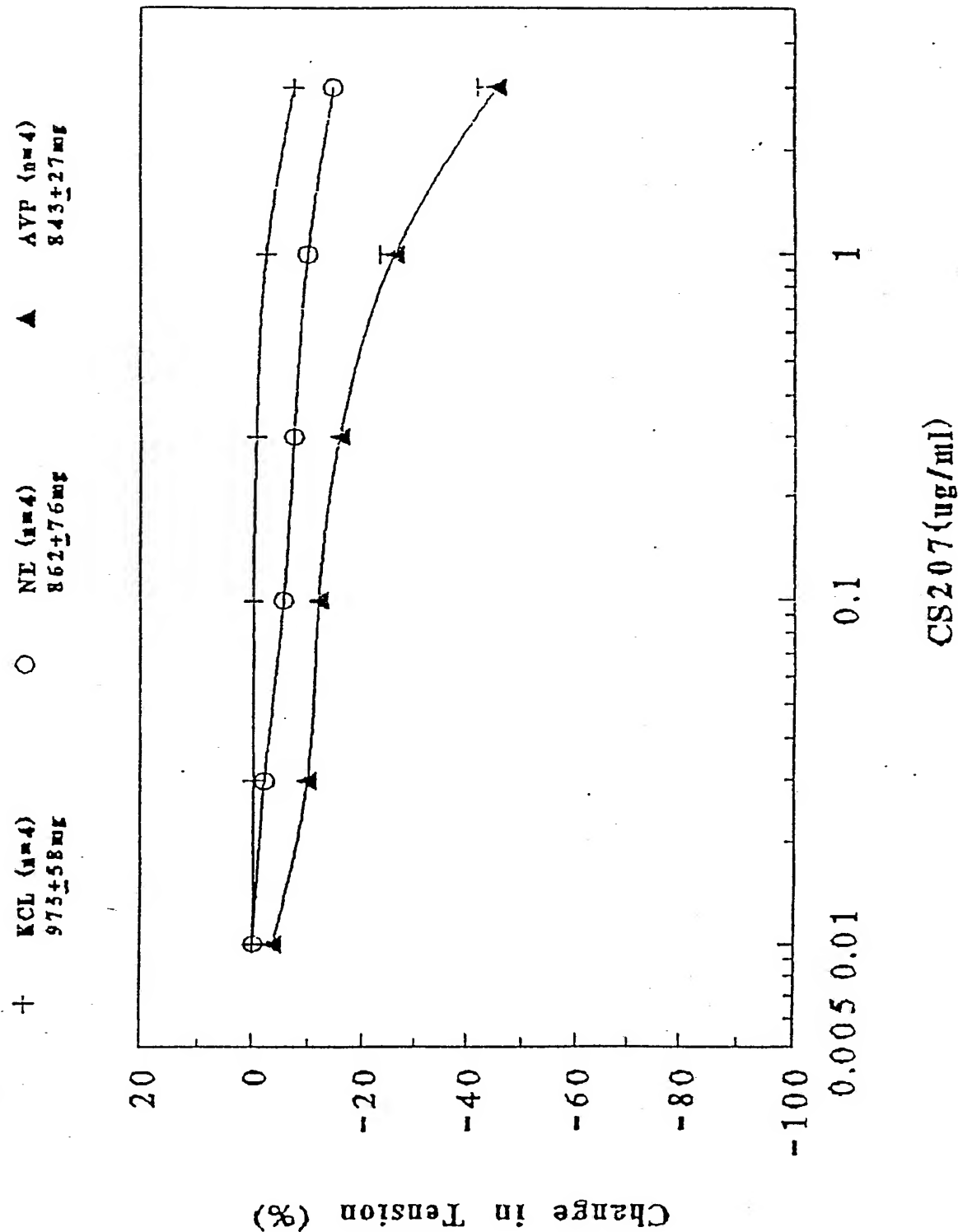
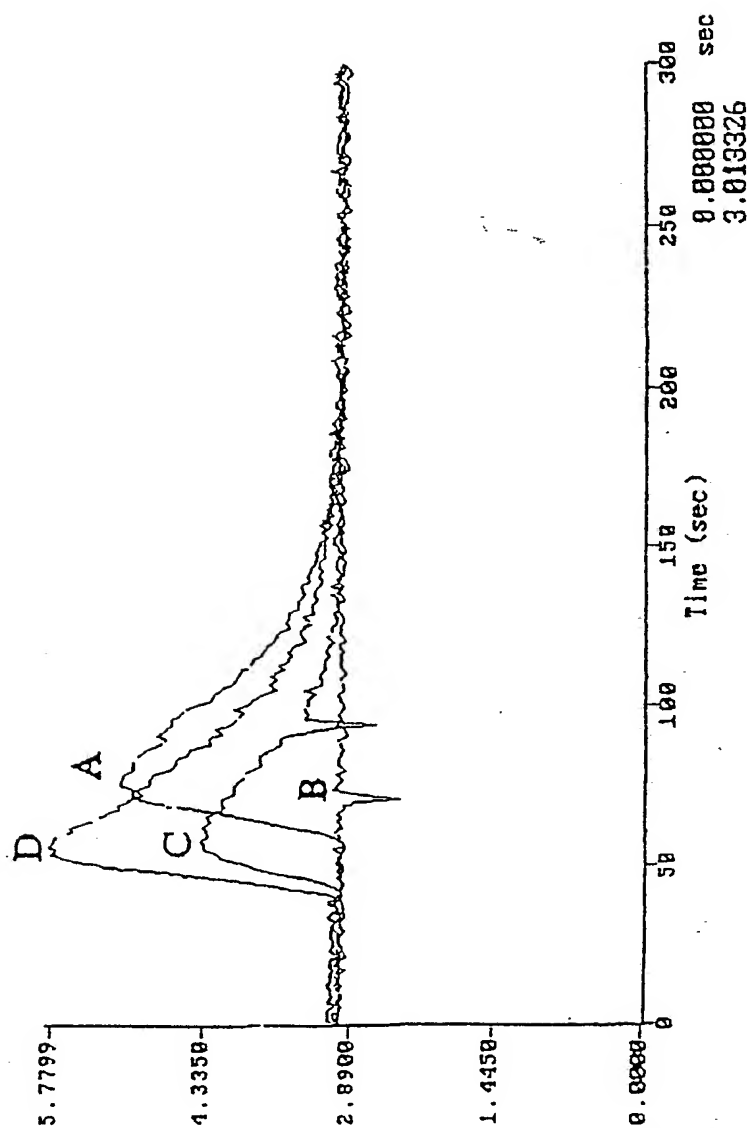


Fig 29

Intracellular Calcium as Ratio of Fluorescence  
(510nm) Intensity (Excitation Wavelength at  
340nm and 380nm)

Effect of CS207 on KCl Stimulated Intracellular  
Free Calcium Concentration in Cultured UMR  
Osteoblast Cells  
Actual Tracing of one Representative Experiment



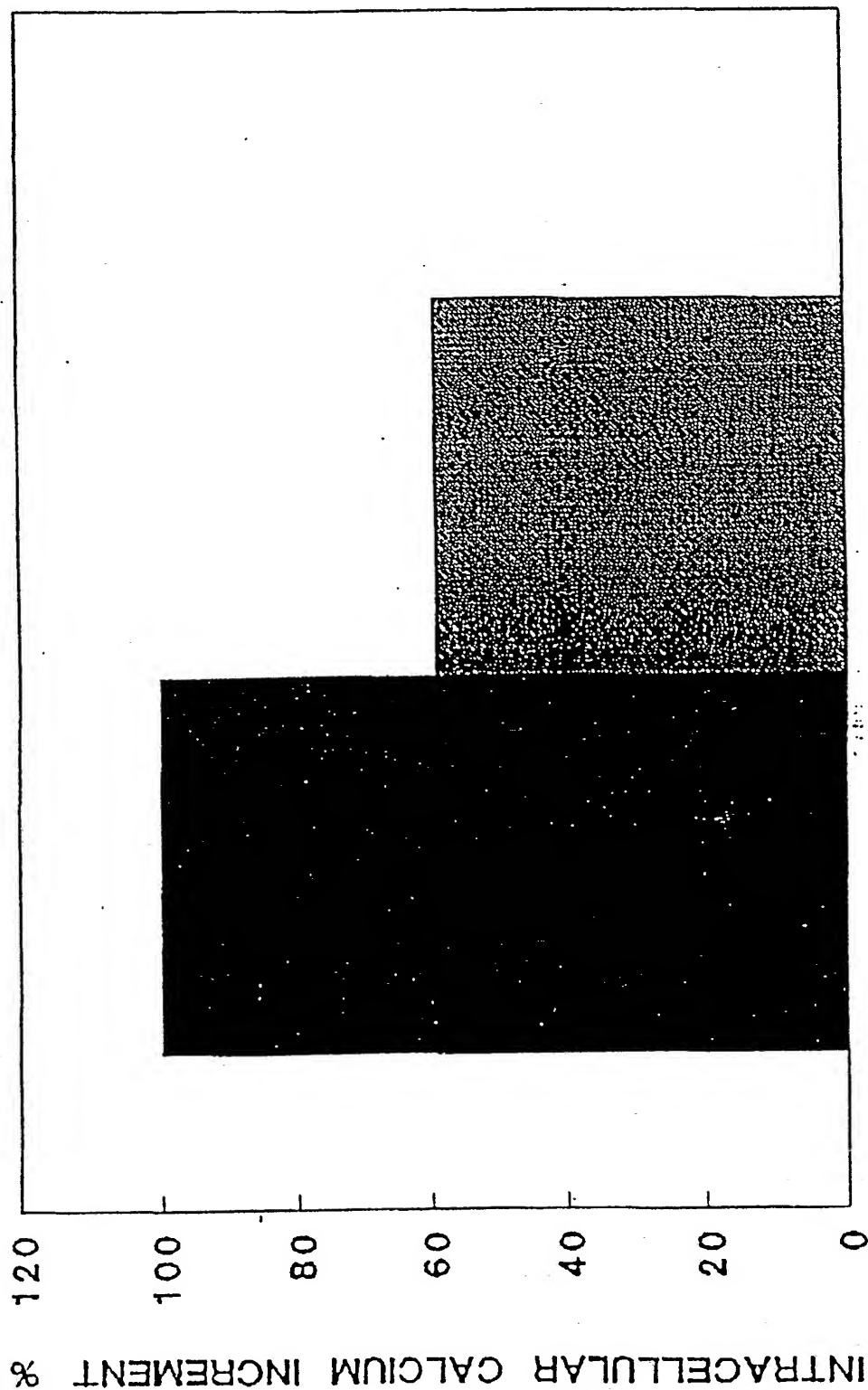
- A. Control KCl 30mM
- B. CS207 2ug/ml
- C. KCl 30mM After CS207 10 Min
- D. KCl 30mM After Wash

Fig 30

EFFECT OF CS207 ON INTRACELLULAR  
CALCIUM INCREMENT INDUCED BY KCL IN UMR

CONTROL  
KCL 30mM

CS207 3ug/ml  
+KCL 30mM



MEAN OF TWO CELLS

Effect of CS206 on Blood Pressure  
of Anesthetized SD Rats (n=8)

+ bPTH(1-34)    ○ CS206  
119±12mmHg    119±8mmHg

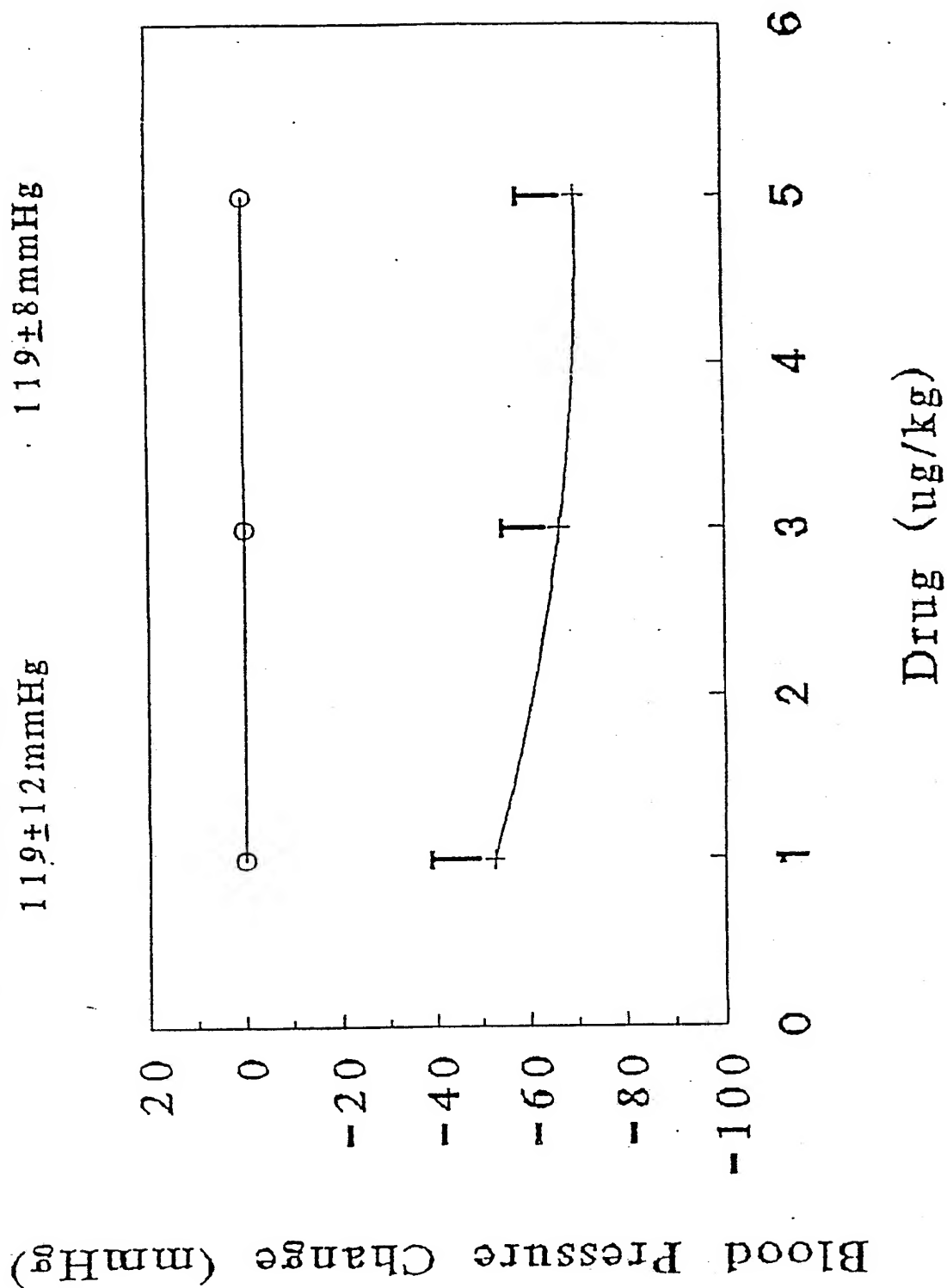


Fig. 32

Dose related relaxation curves produced by drug CS206 on SD rat tail artery helical strips precontracted with KCL (60mM), NE (10<sup>-6</sup>M) or AVP (10<sup>-6</sup>M)

+ KCL (n=4) 693±56mg      ○ NE (n=4) 886±86mg      ▲ AVP (n=4) 637±33mg

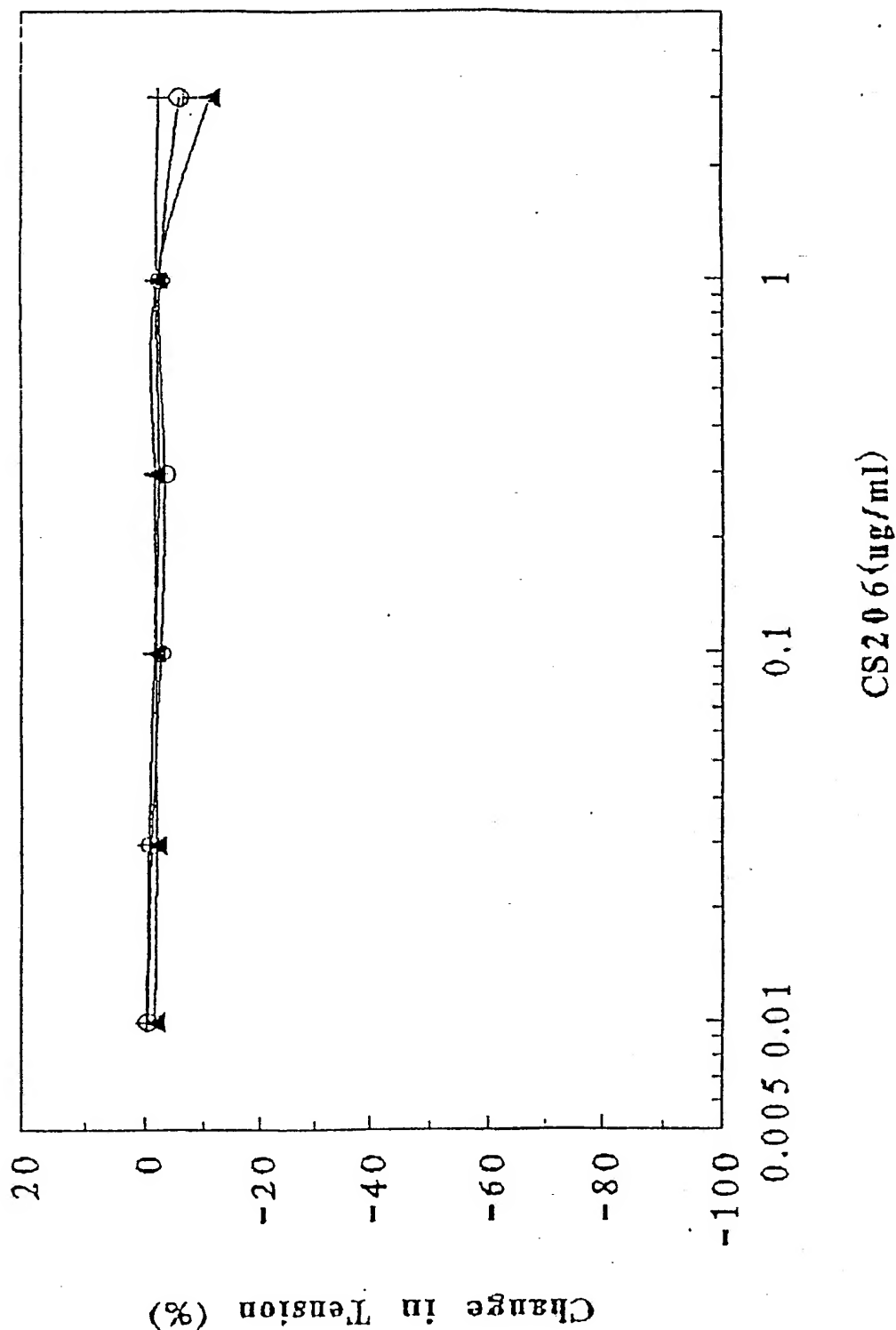


Fig-33

Effect of CS206 on KCl Stimulated Intracellular  
Free Calcium Concentration in Cultured UMR  
Osteoblast Cells  
Actual Tracing of one Representative Experiment

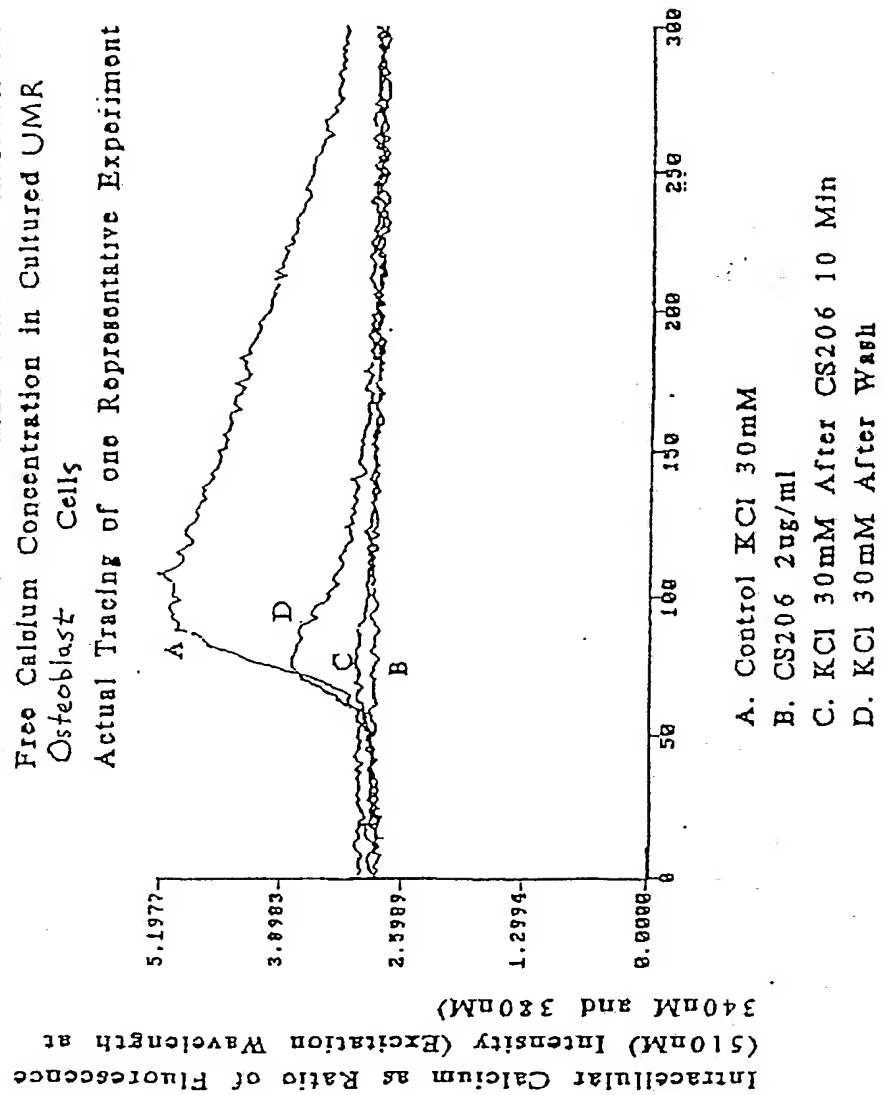
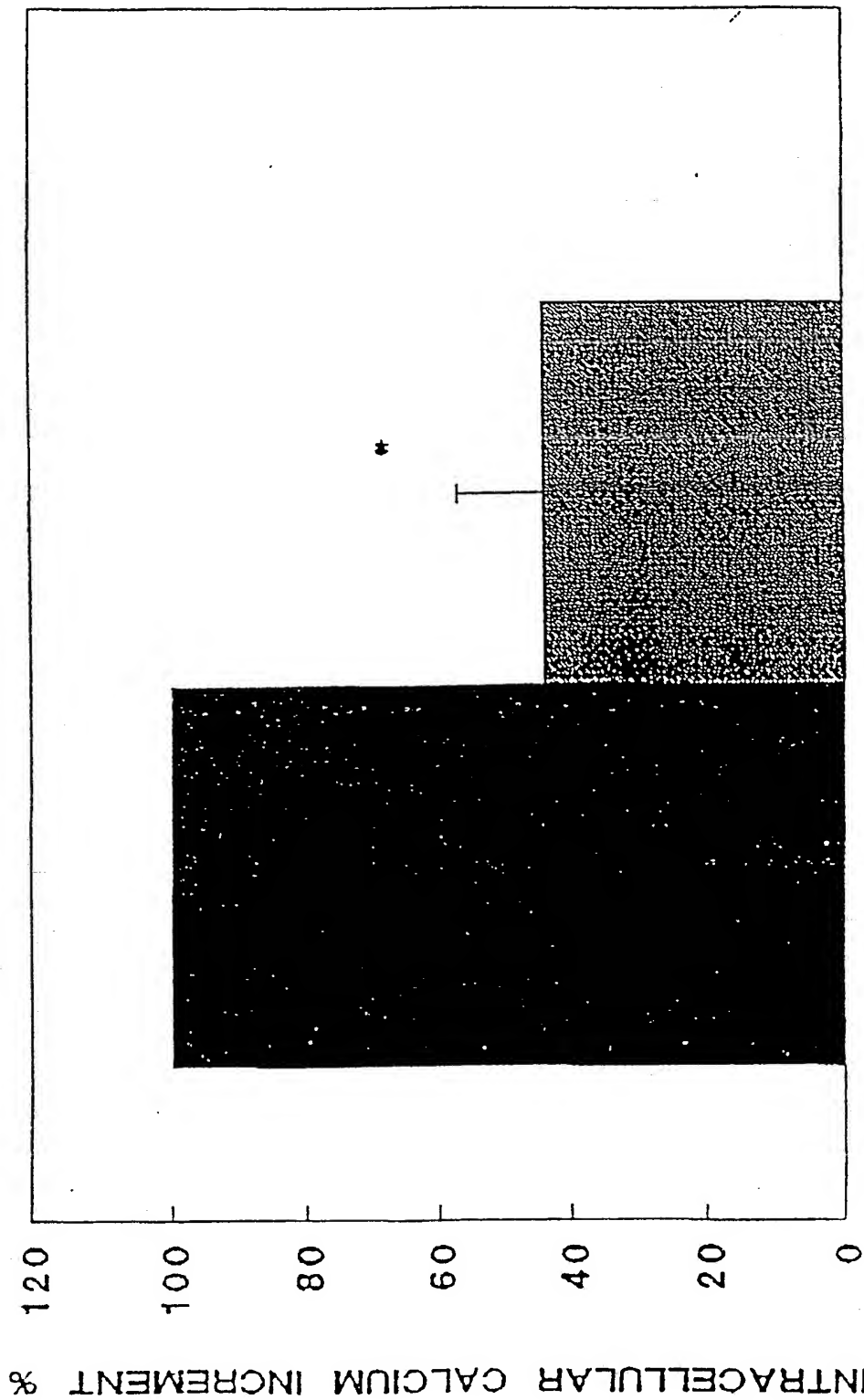


Fig. 34

EFFECT OF CS206 ON INTRACELLULAR  
CALCIUM INCREMENT INDUCED BY KCL IN UMR

 CONTROL  
 CS206 3ug/ml  
 +KCL 30mM



\* P<0.05

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Effect of CS114 on S.B.P  
in Anesthetized SD Rats (n=8)

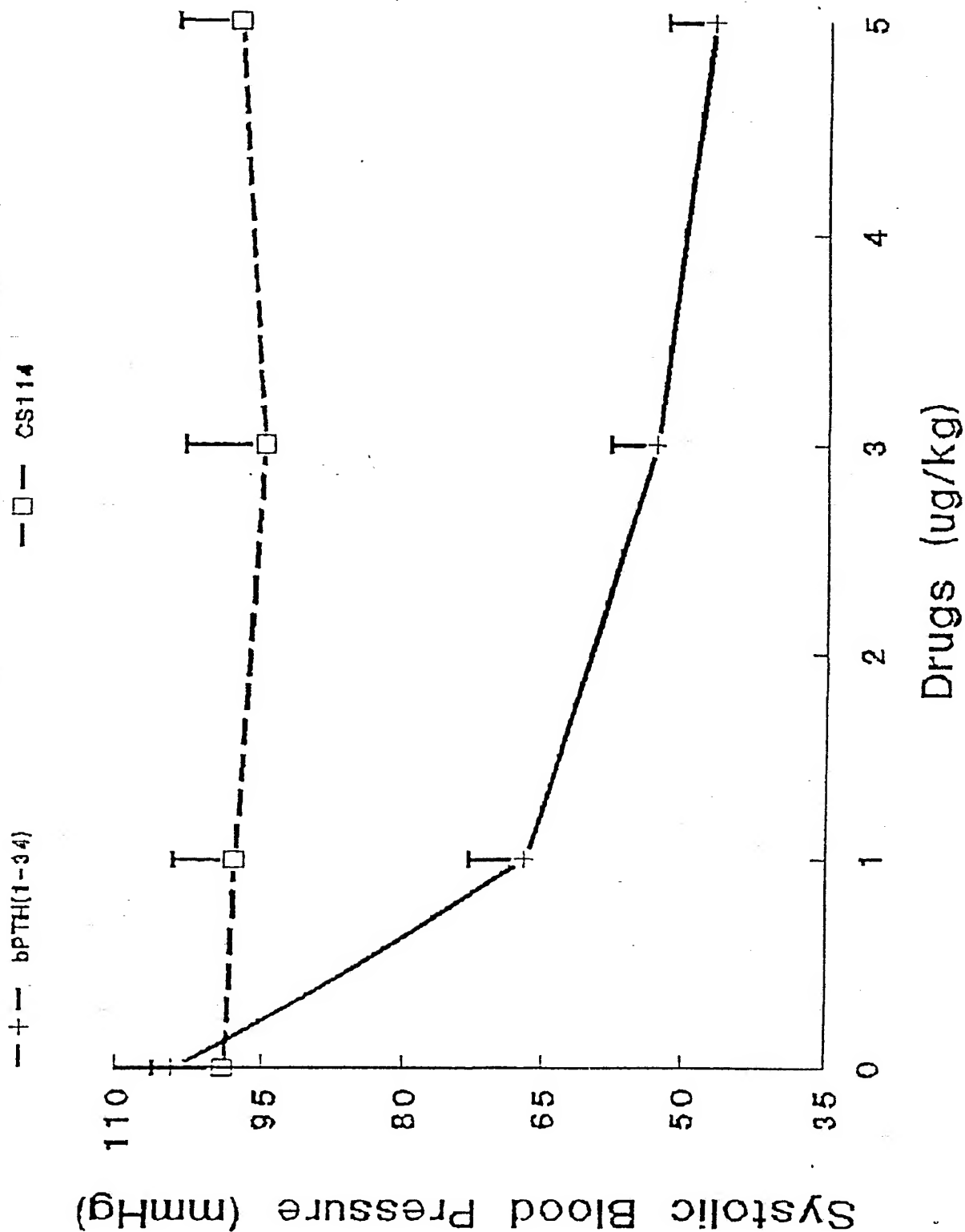


Fig. 35

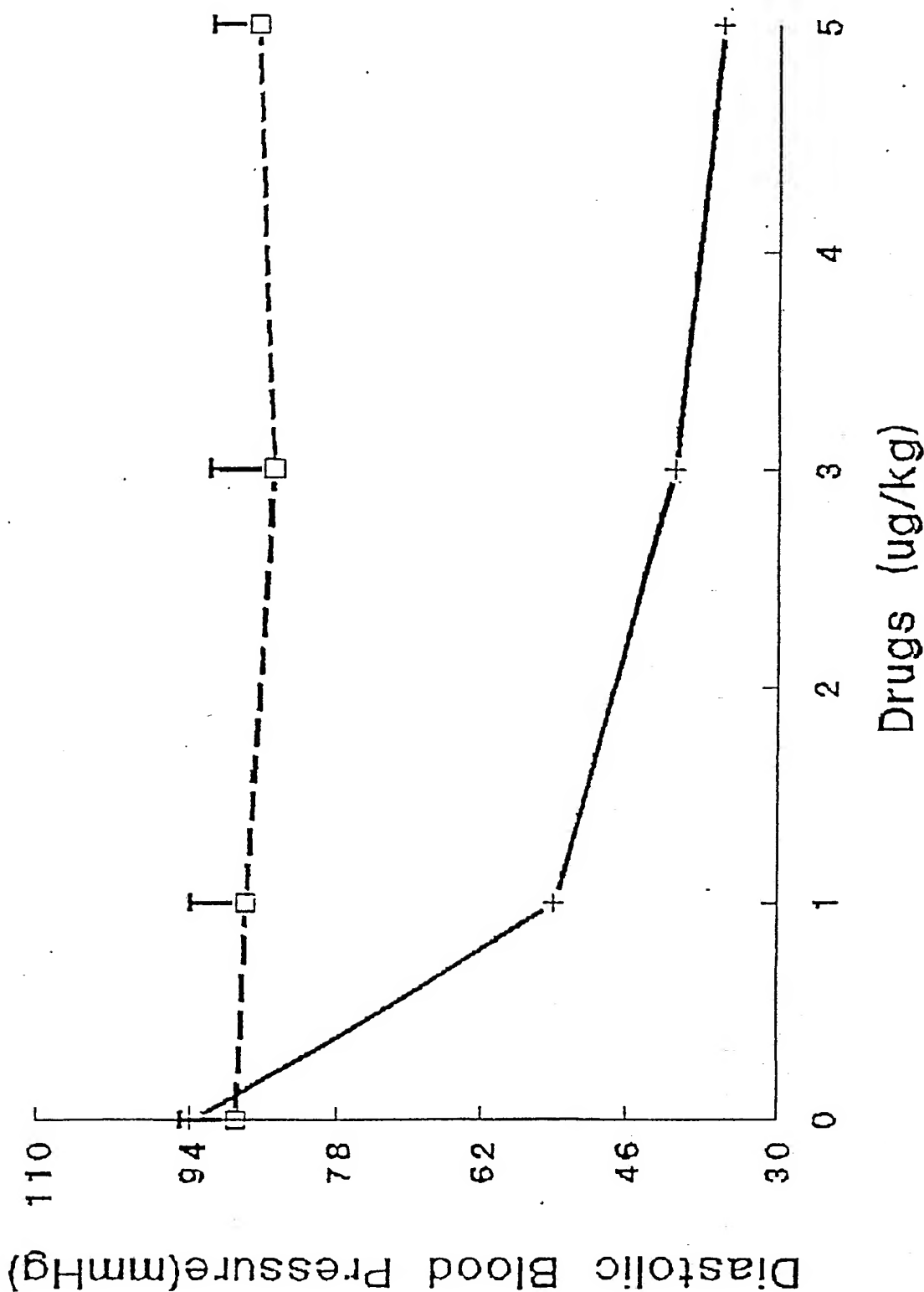
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Fig-36

Effect of CS114 on D.B.P  
in Anesthetized SD Rats (n=8)

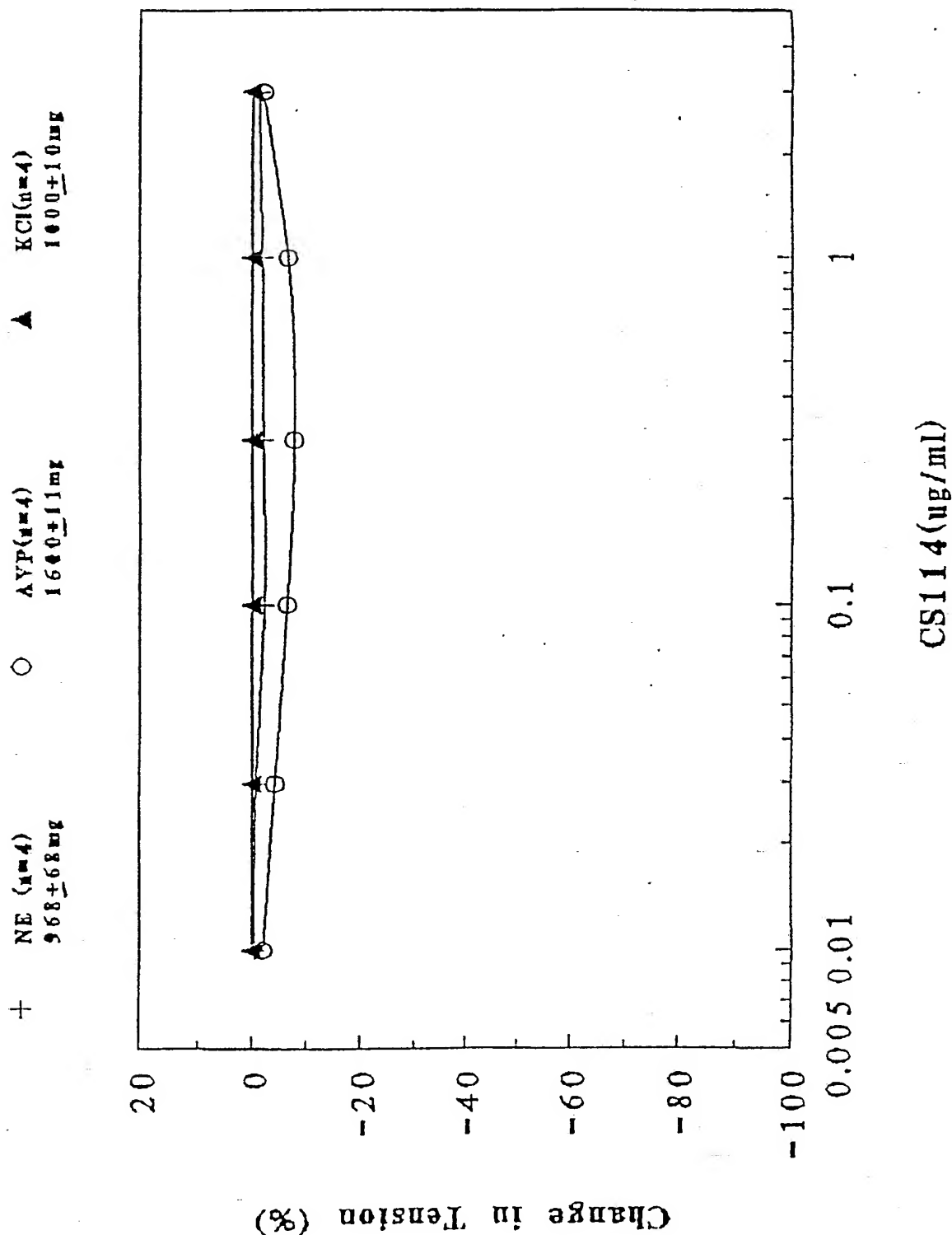
--□-- CS114

--+-- bPTH(1-34)



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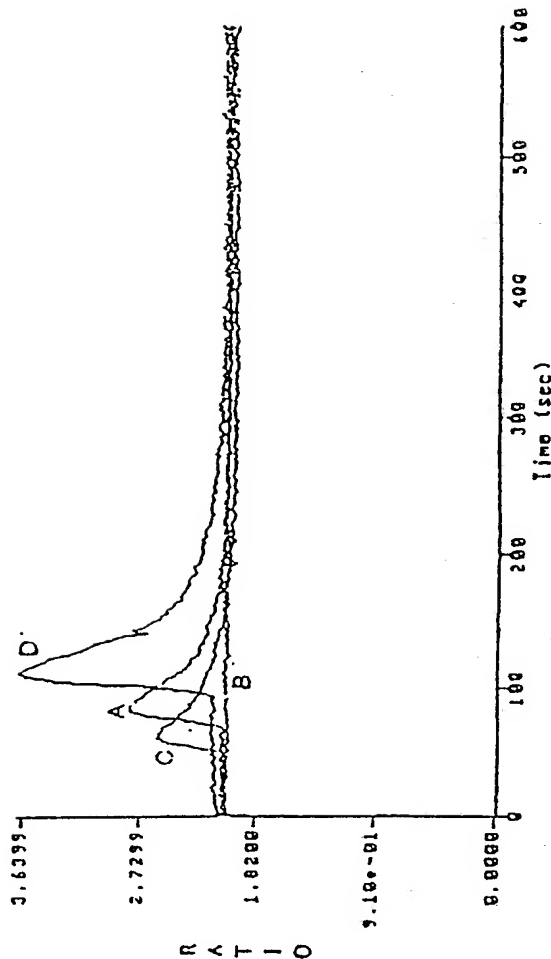
Fig. 37. Dose related relaxation curves produced by drug CS114 on SD rat tail artery helical strips precontracted with NE ( $10^{-6}$ M), AVP ( $10^{-6}$ M) or KCl (60mM)



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Intracellular Calcium as Ratio of Fluorescence  
(510nm) Intensity (Excitation Wavelength at  
340nm and 380nm)

# Effect of CS114 on KCl Stimulated Intracellular Free Calcium Concentration in Cultured UMR Osteoblast Cells Actual Tracing of one Representative Experiment



- A. Control KCl 15mM
- B. CS114 2.5X10-6M
- C. KCl 15mM After CS114 10 Min
- D. KCl 15mM After Wash

Fig 38

4/10/07

Fig. 39

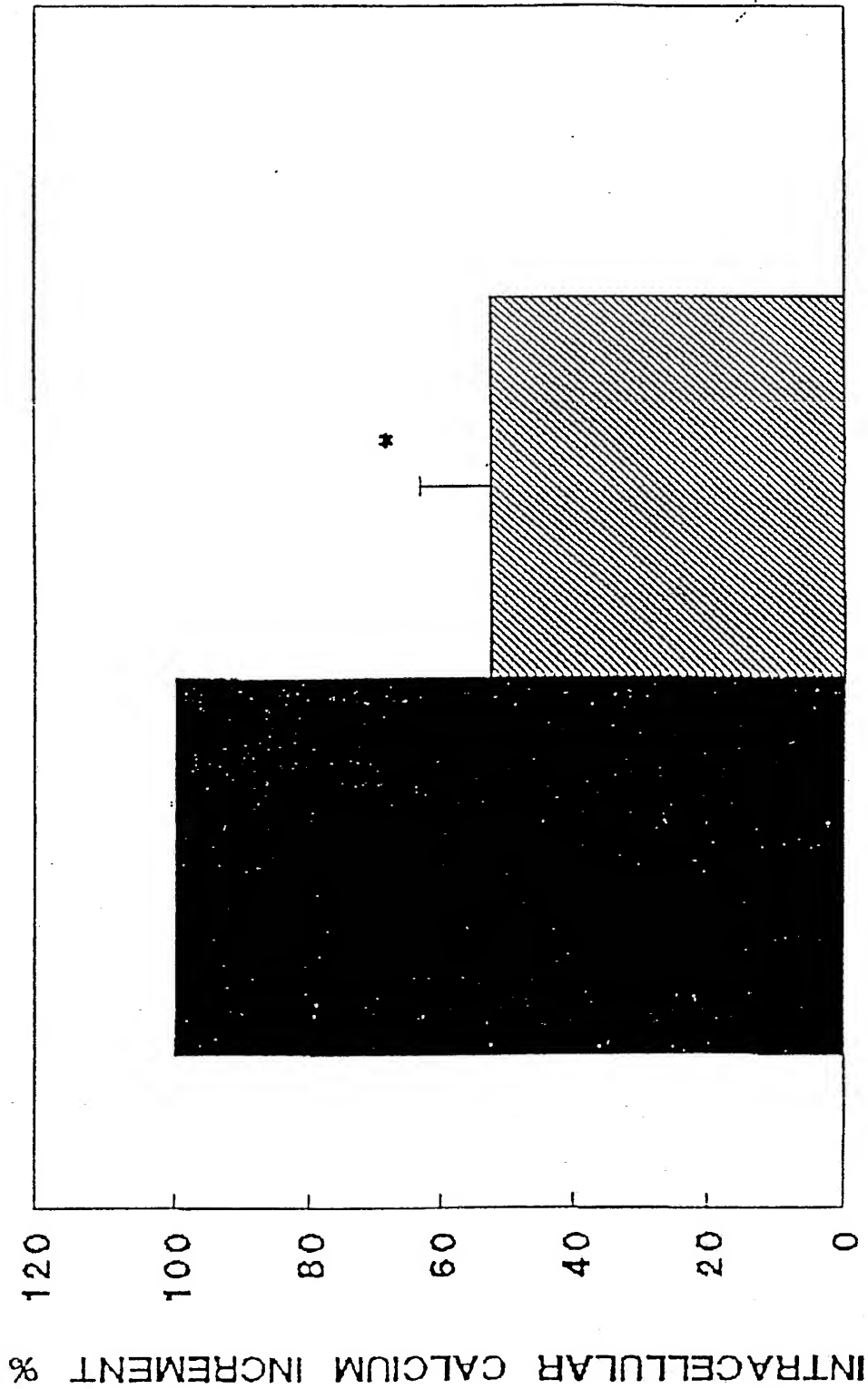
EFFECT OF CS114(A) ON INTRACELLULAR  
CALCIUM INCREMENT INDUCED BY KCL IN UMR



CONTROL  
KCL 15mM



CS114 3 uM  
+KCL 15mM



\*  $P < 0.05$

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Effect of CS114(B) on Intracellular  
Calcium Increment Induced by KCl in UMR

Control  
KCl 30mM

CS114(B)  
+KCl 30mM

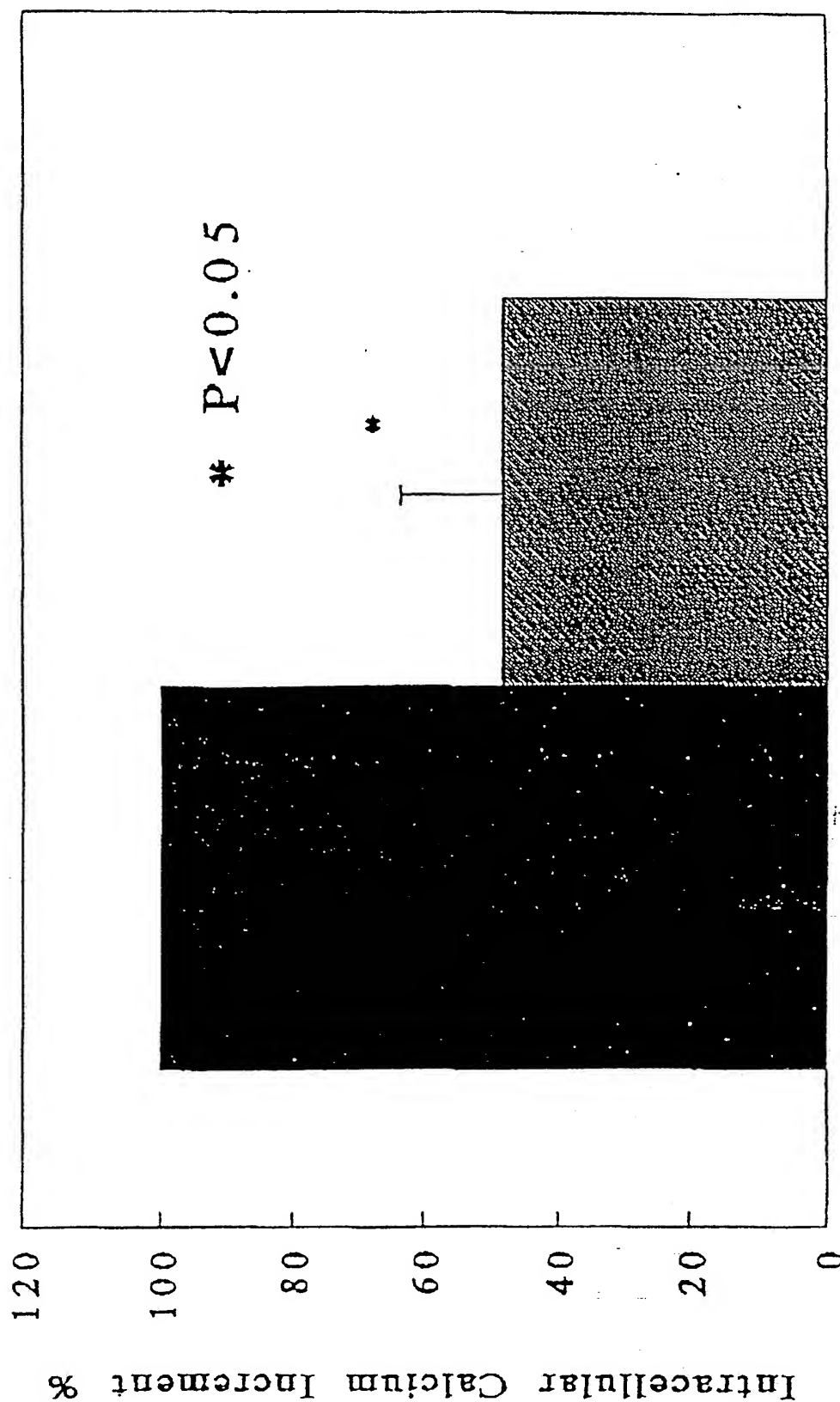
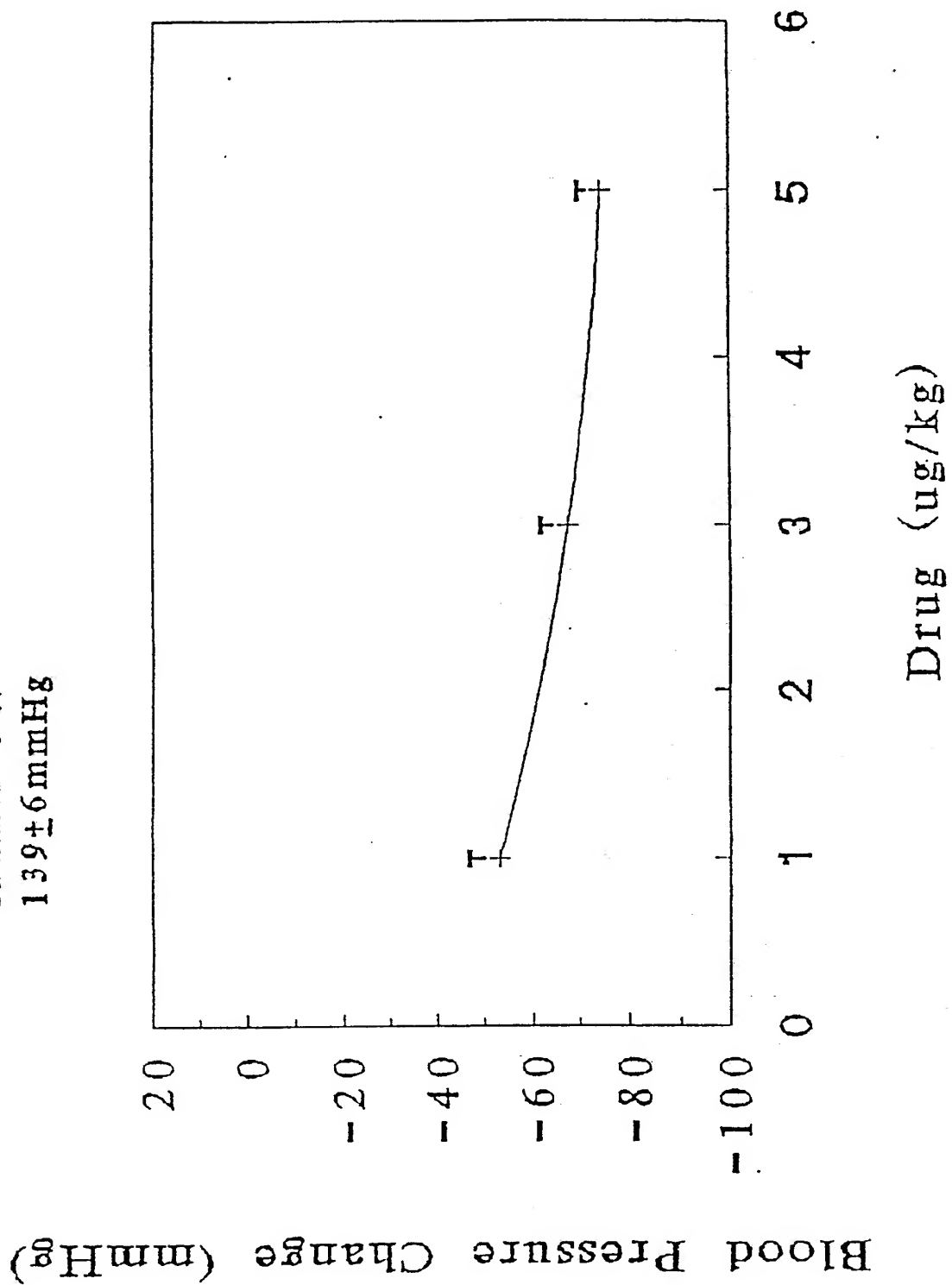


Fig. 40

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Fig. 41  
Effect of CS88 on Blood Pressure  
of Anesthetized SD Rats (n=8)

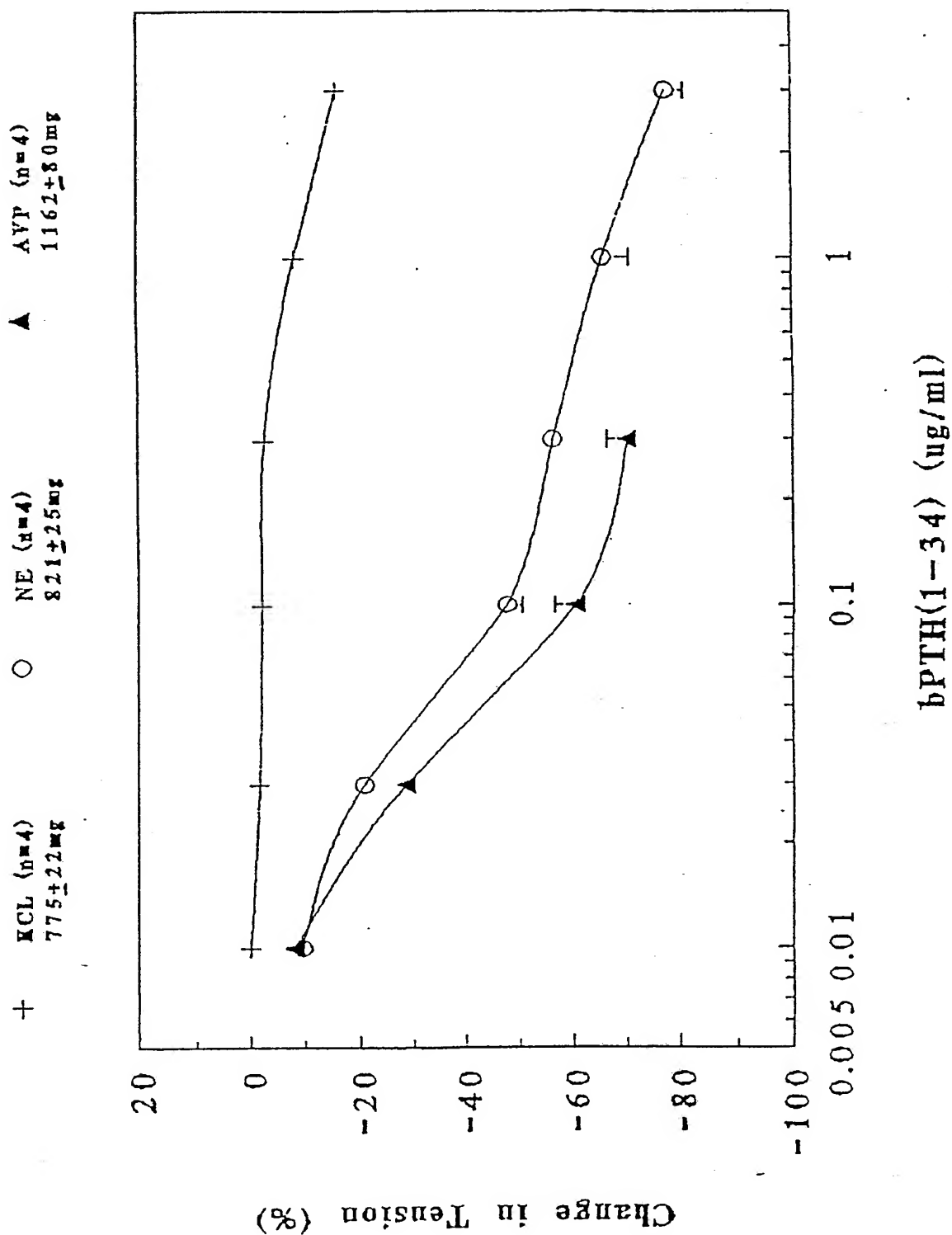
+ bPTH(1-34)  
139±6mmHg



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Dose related relaxation curves produced by drug bPTH on SD rat tail artery helical strips precontracted with KCL (60mM), NE (3x10<sup>-6</sup>M) or AVP 10<sup>-8</sup>M)

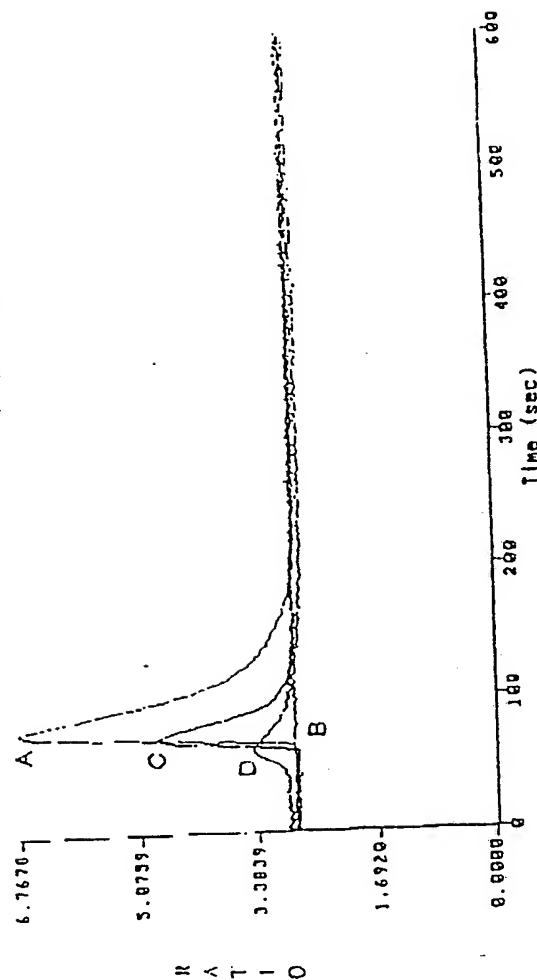
Fig 42



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Effect of CS88 on KCl Stimulated intracellular  
Free Calcium Concentration in Cultured UMR  
Osteoblast Cells  
Actual Tracing of one Representative Experiment

- A CONTROL KCL 15mM
- B PTH 2.5X18-6H
- C KCL 15mM AFTER PTH 18MIN
- D KCL 15mM AFTER WASH



Intracellular Calcium as Ratio of Fluorescence  
(510nm) Intensity (Excitation Wavelength at  
340nm and 380nm)

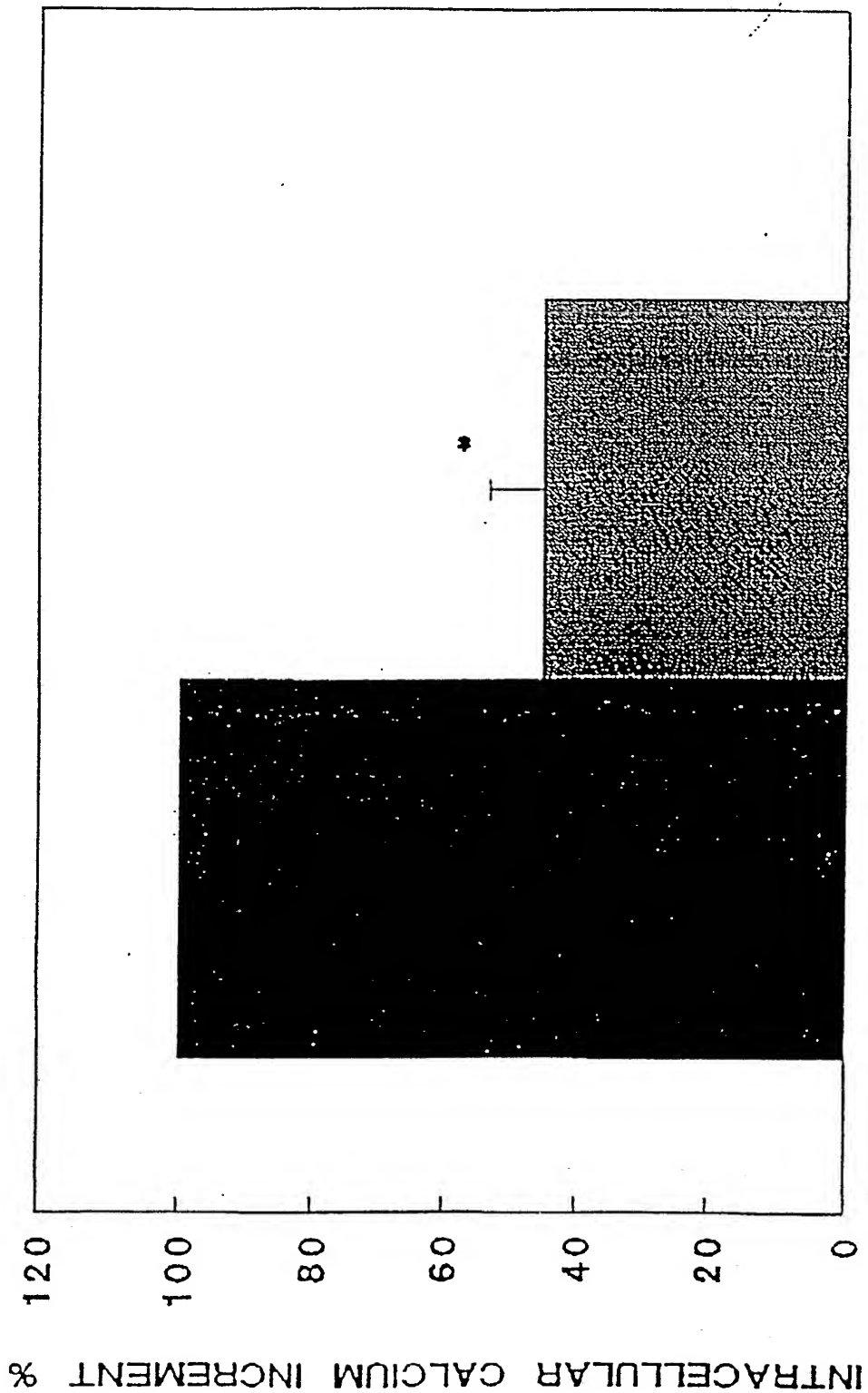
Fig. 43

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EFFECT OF CS88 ON INTRACELLULAR  
CALCIUM INCREMENT INDUCED BY KCL IN UMR

CS88 3  $\mu$ M  
KCL 15mM

CONTROL  
KCL 15mM



\*  $P < 0.05$

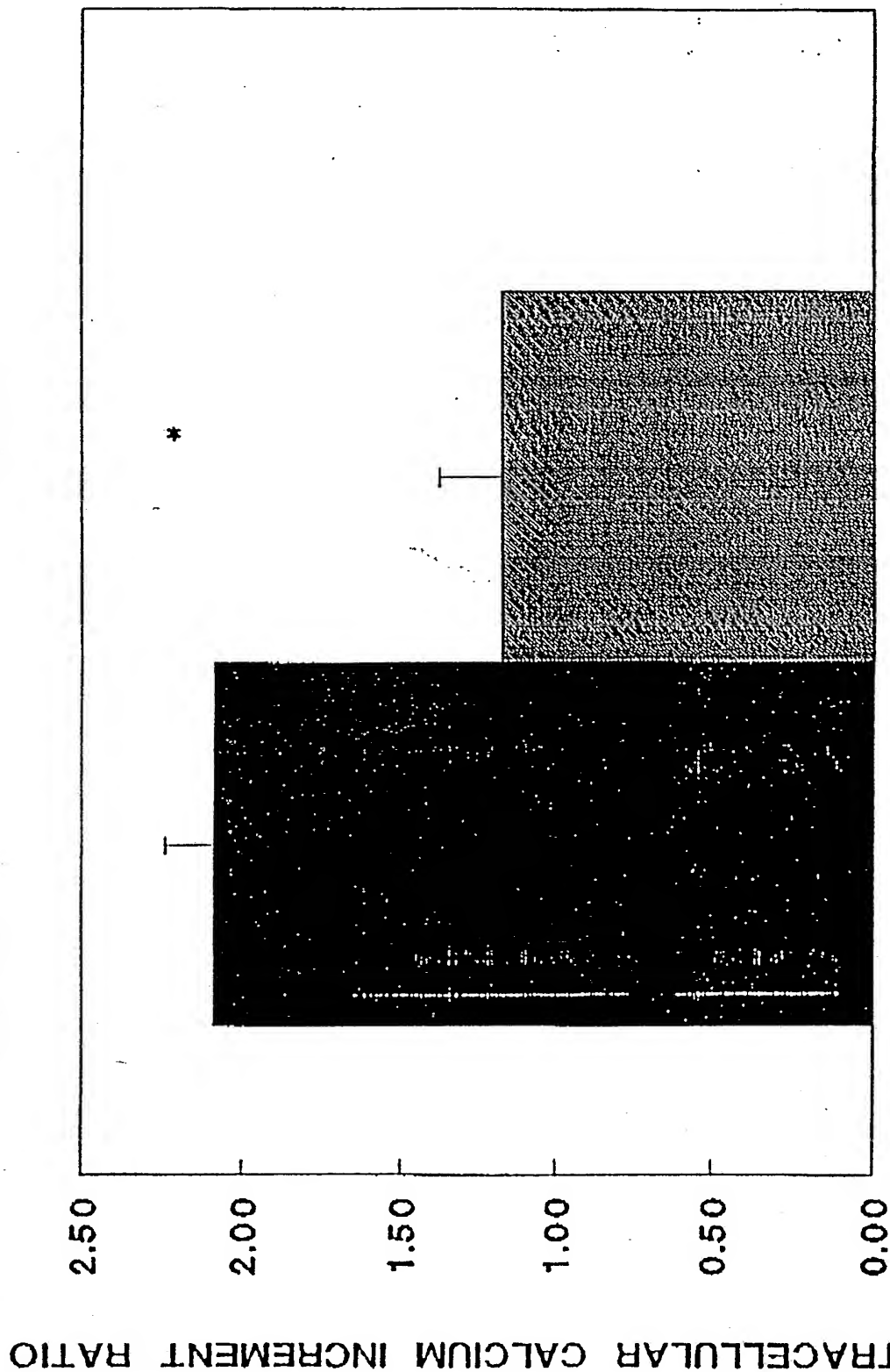
Fig. 44

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EFFECT OF CS 113 ON INTRACELLULAR  
CALCIUM INCREMENT IN UMR(106)

CONTROL  
KCL 15mM

CS 113  
20UG/ML



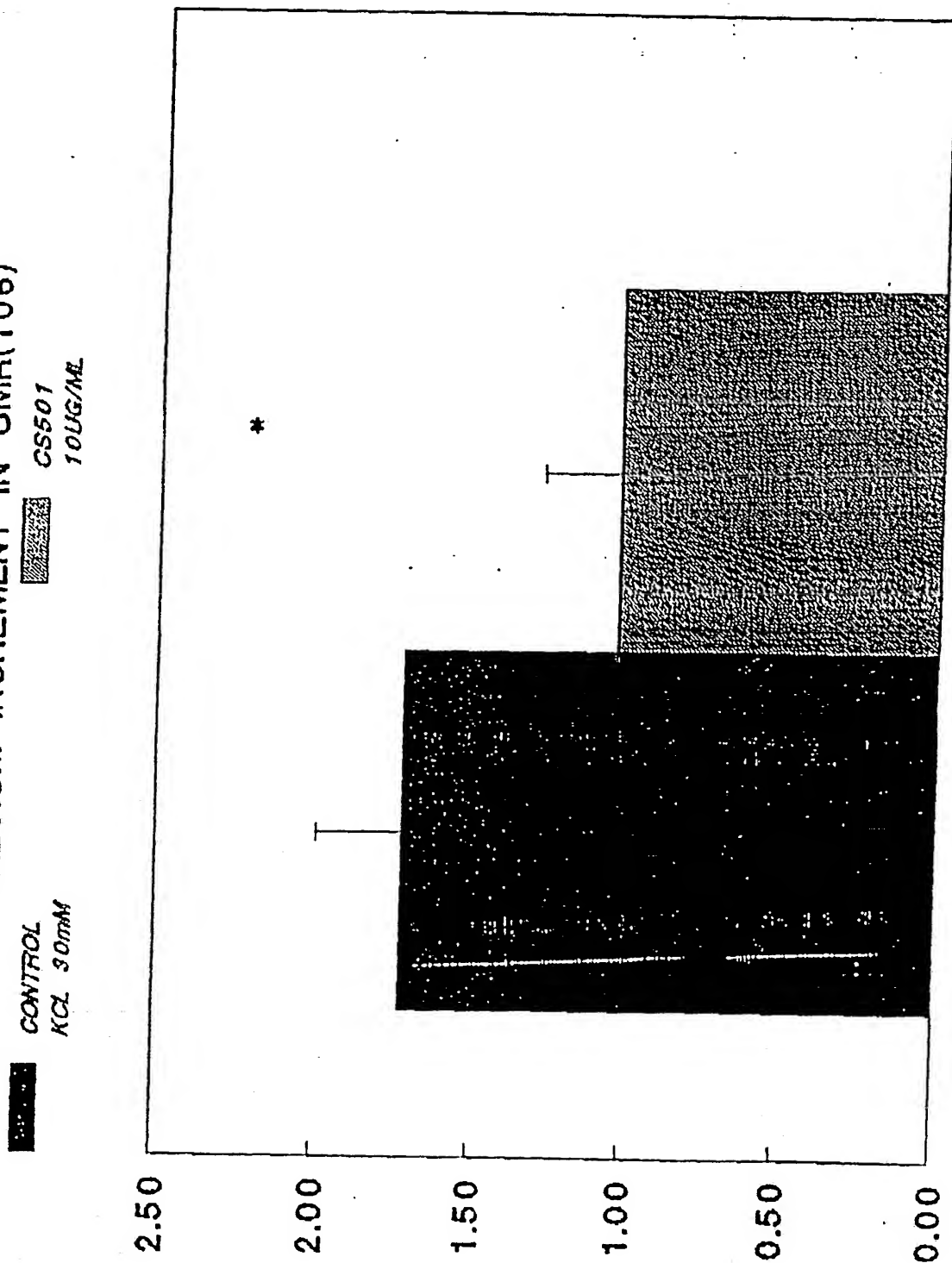
\* P<0.05, MEAN VALUE OF FOR CELLS

Fig. 45

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Fig. 46

EFFECT OF CS 501 ON INTRACELLULAR  
CALCIUM INCREMENT IN UMR(106)



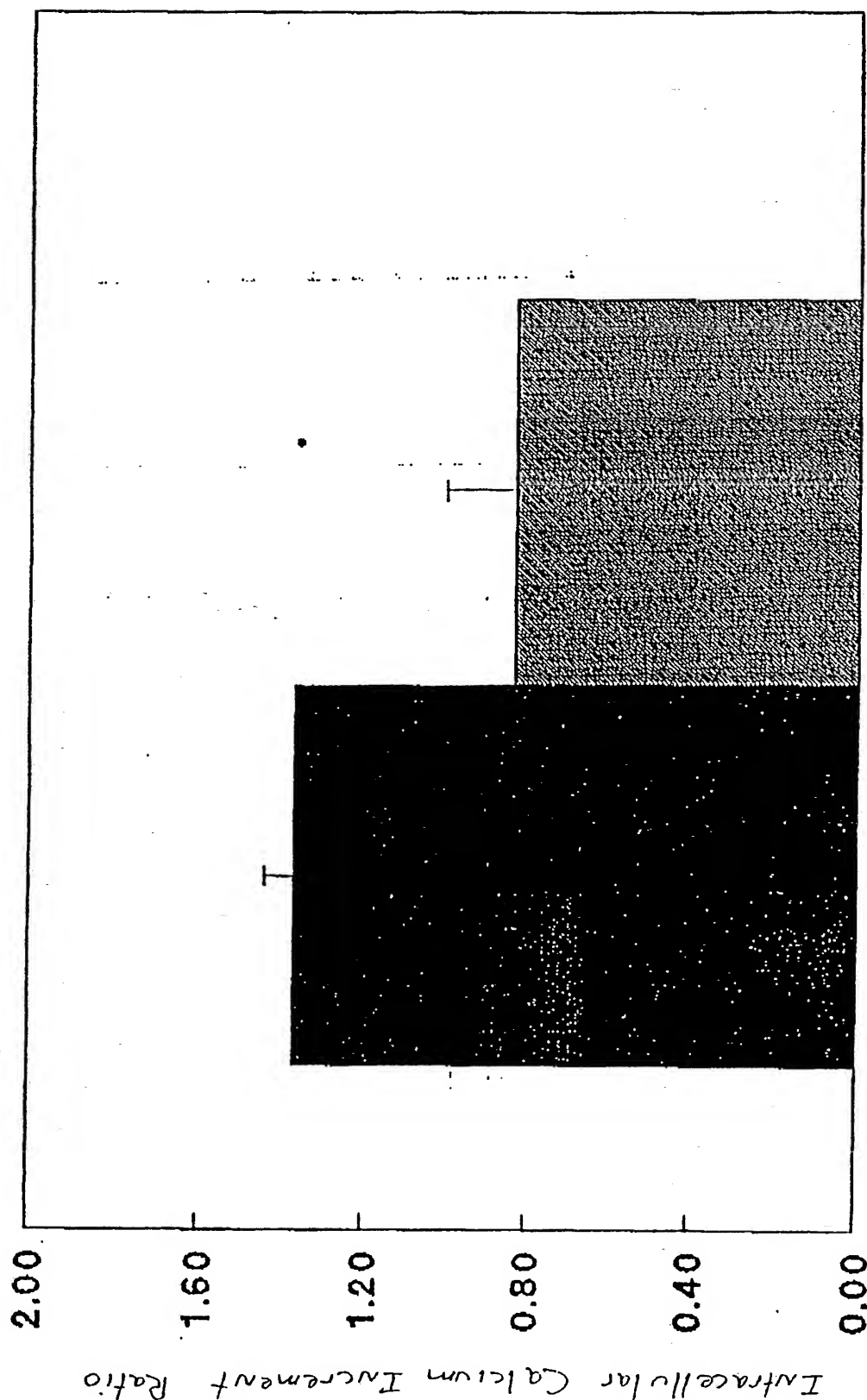
\*  $P < 0.01$ , MEAN VALUE OF FOUR CELLS

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Fig 47

EFFECT OF CS 1001 ON INTRACELLULAR  
CALCIUM INCREMENT IN UMR(106)

CONTROL CS1001  
KCL 30mM 1UG/ML



\* P<0.05, MEAN VALUE OF FIVE CELLS

Fig 48

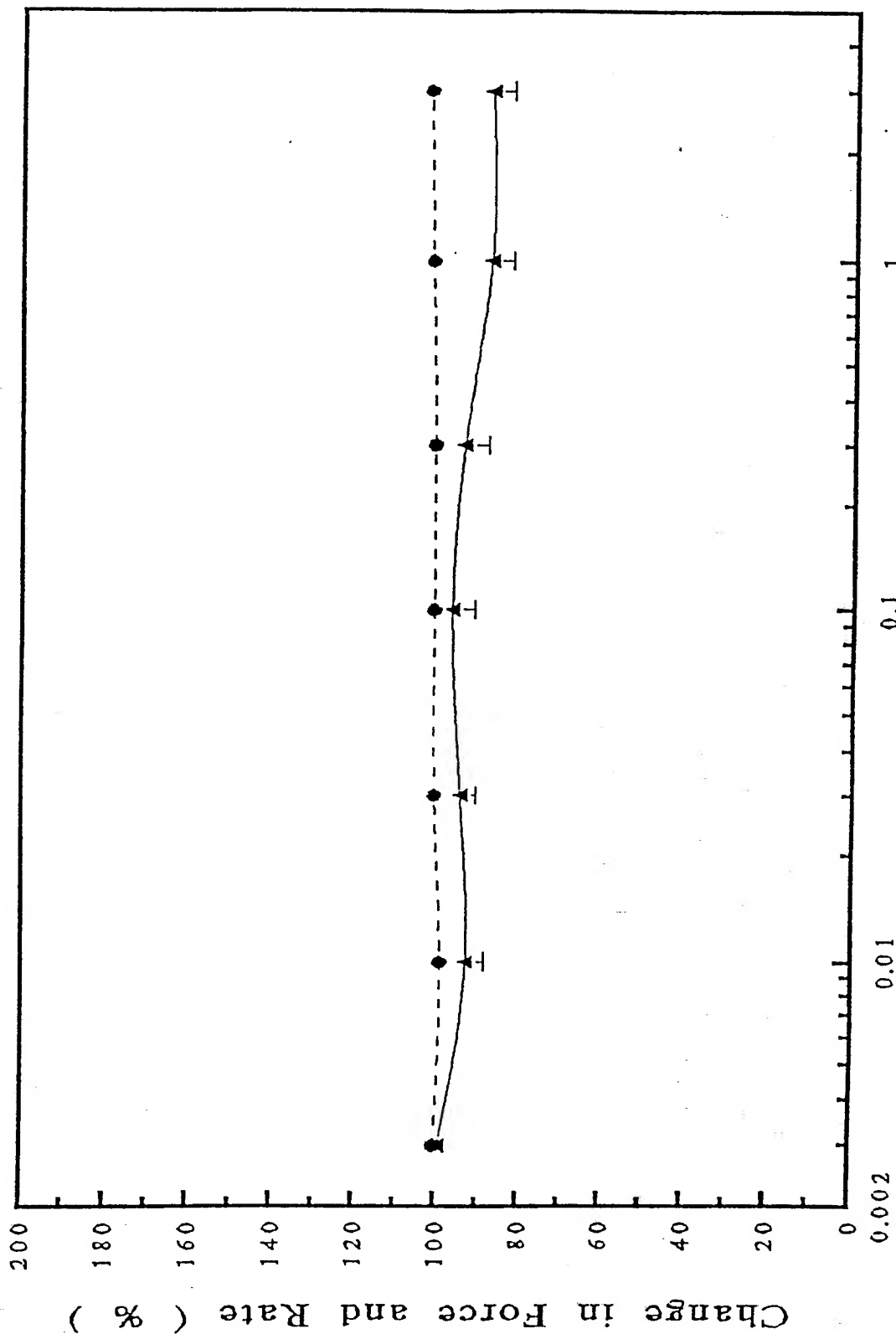
Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS114

WO 93/06846

4/9/67

PCT/US92/08478

▲ Contractility 193.8 ± 42.5 mg (n=4) ● Contraction rate 370 ± 20.4 beats/min (n=4)



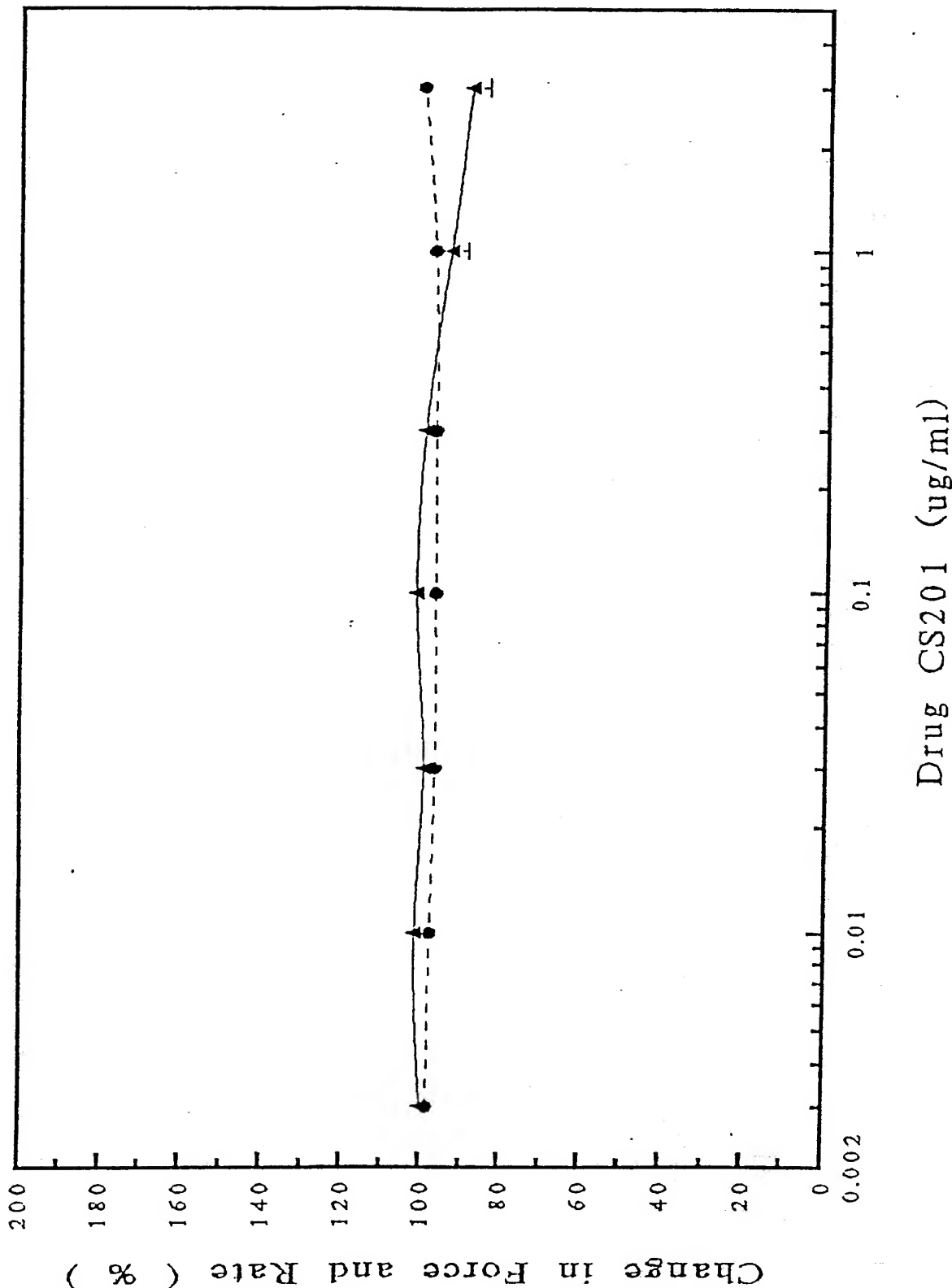
Drug CS114 (µg/ml)

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Fig 49

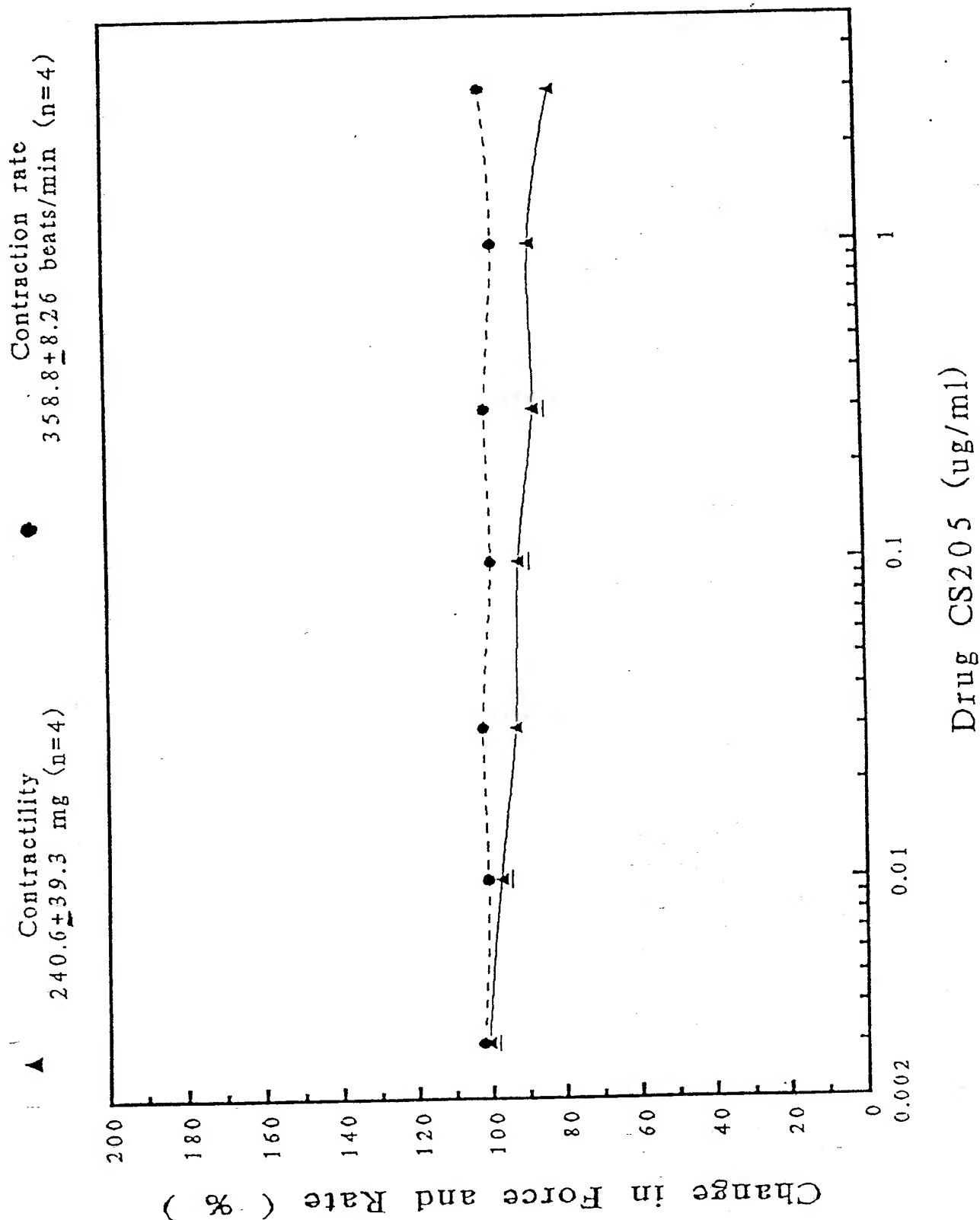
Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS201

▲ Contractility 131.3±25.8 mg (n=4) ● Contraction rate 372.5±20.6 beats/min (n=4)



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Fig 50 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS205



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Fig. 51 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS206

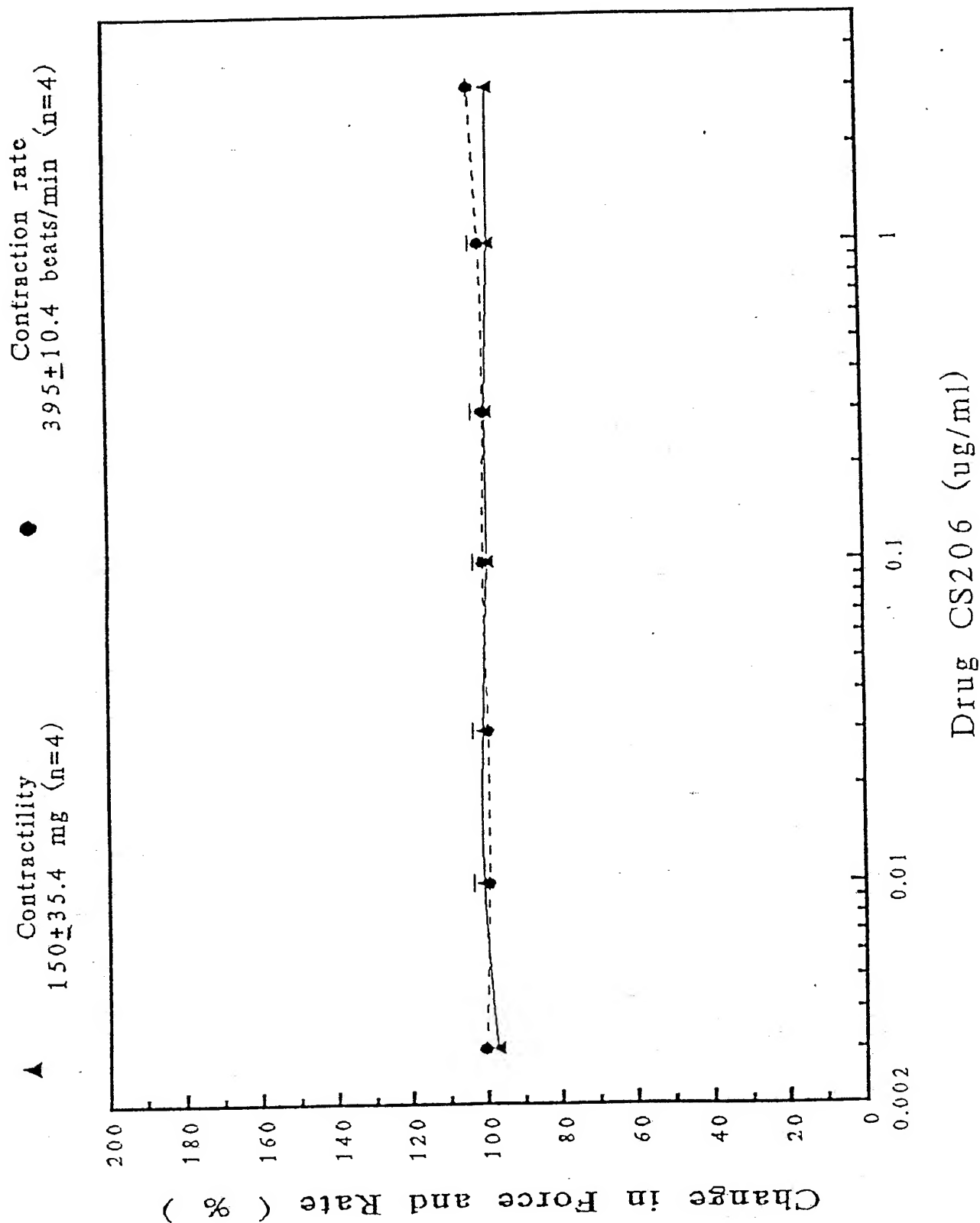
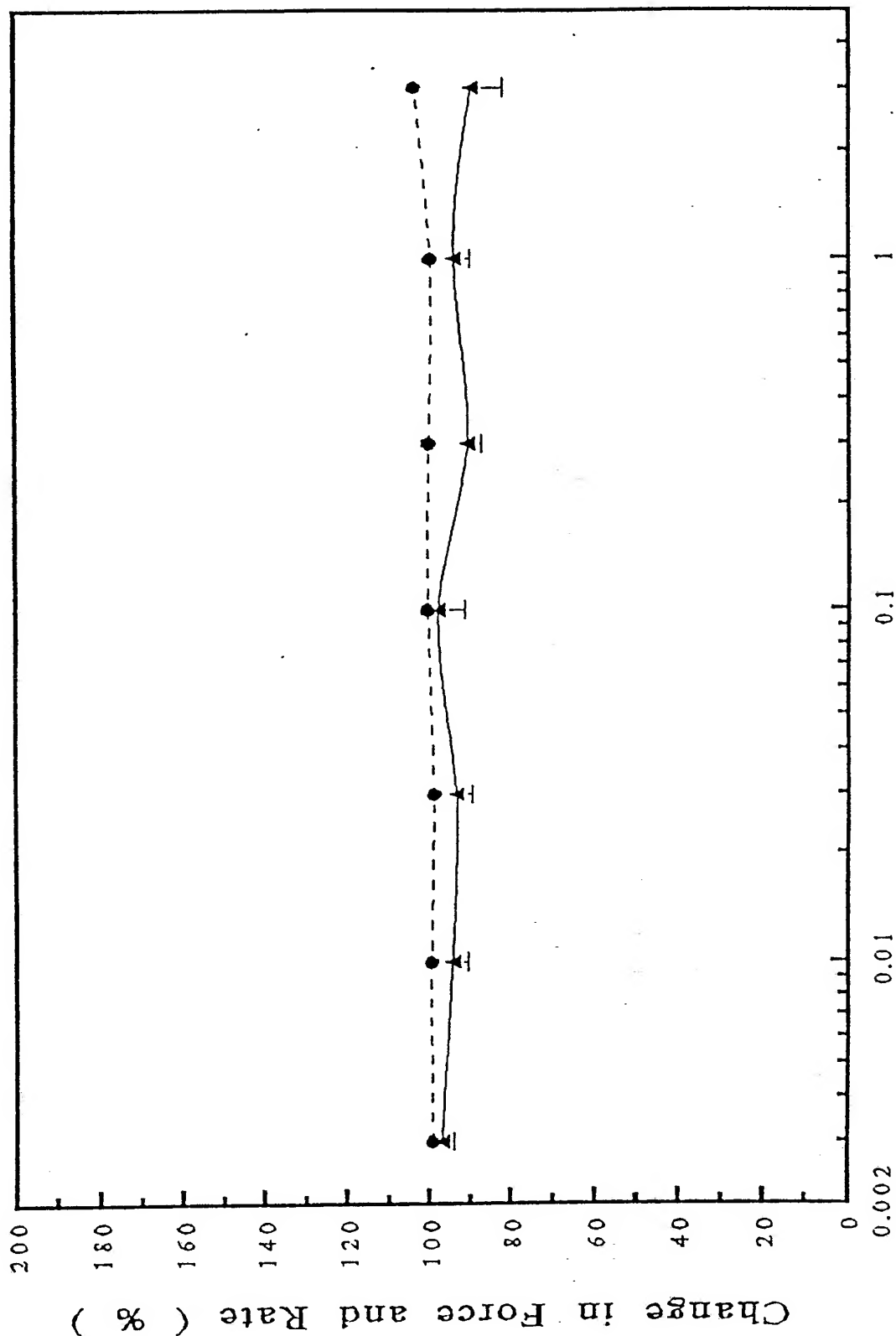


Fig. 52

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS207

▲ Contractility 125 ± 28.4 mg (n=4)  
● Contraction rate 427.5 ± 4.78 beats/min (n=4)



Drug CS207 (µg/ml)

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Fig 53 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS208

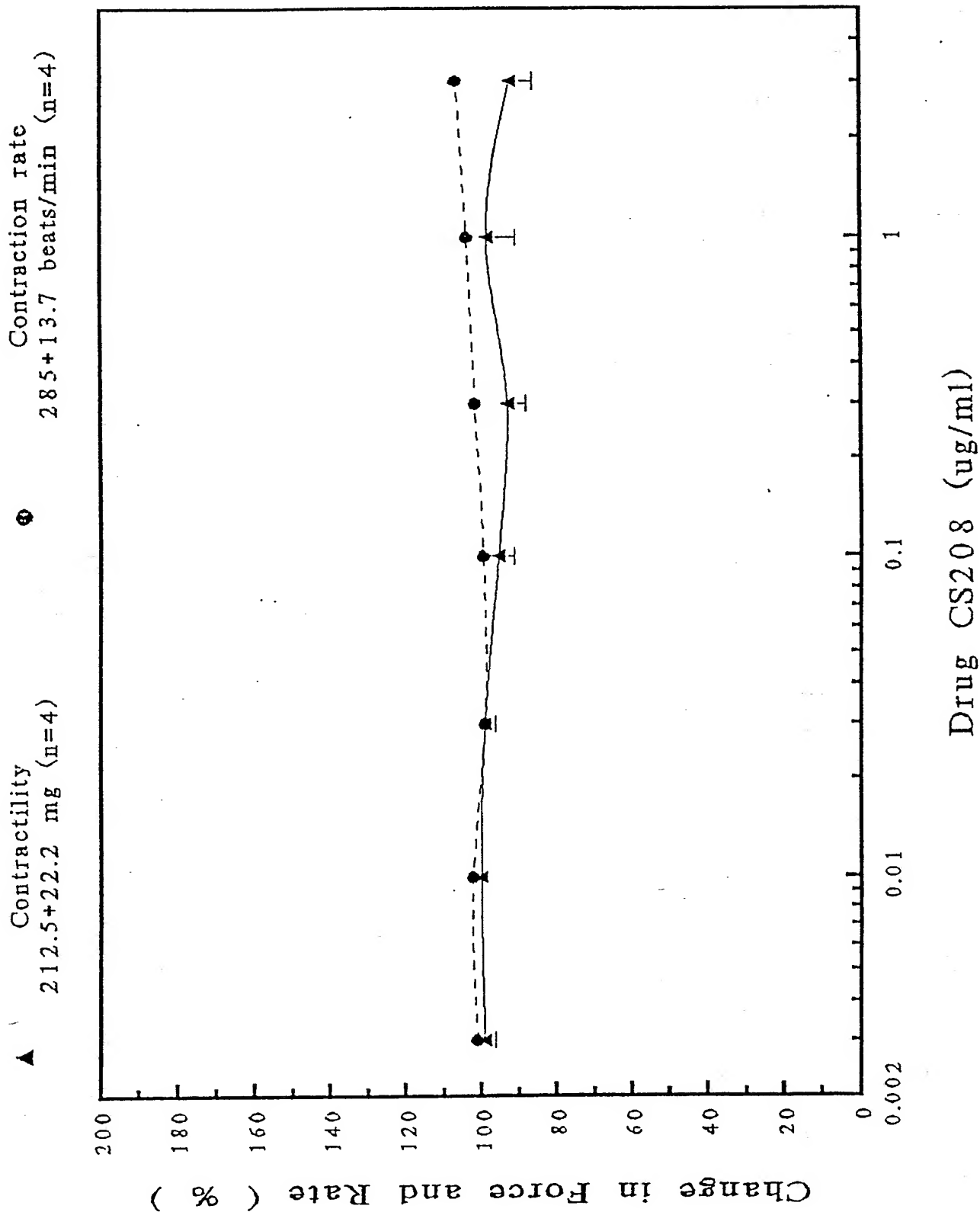
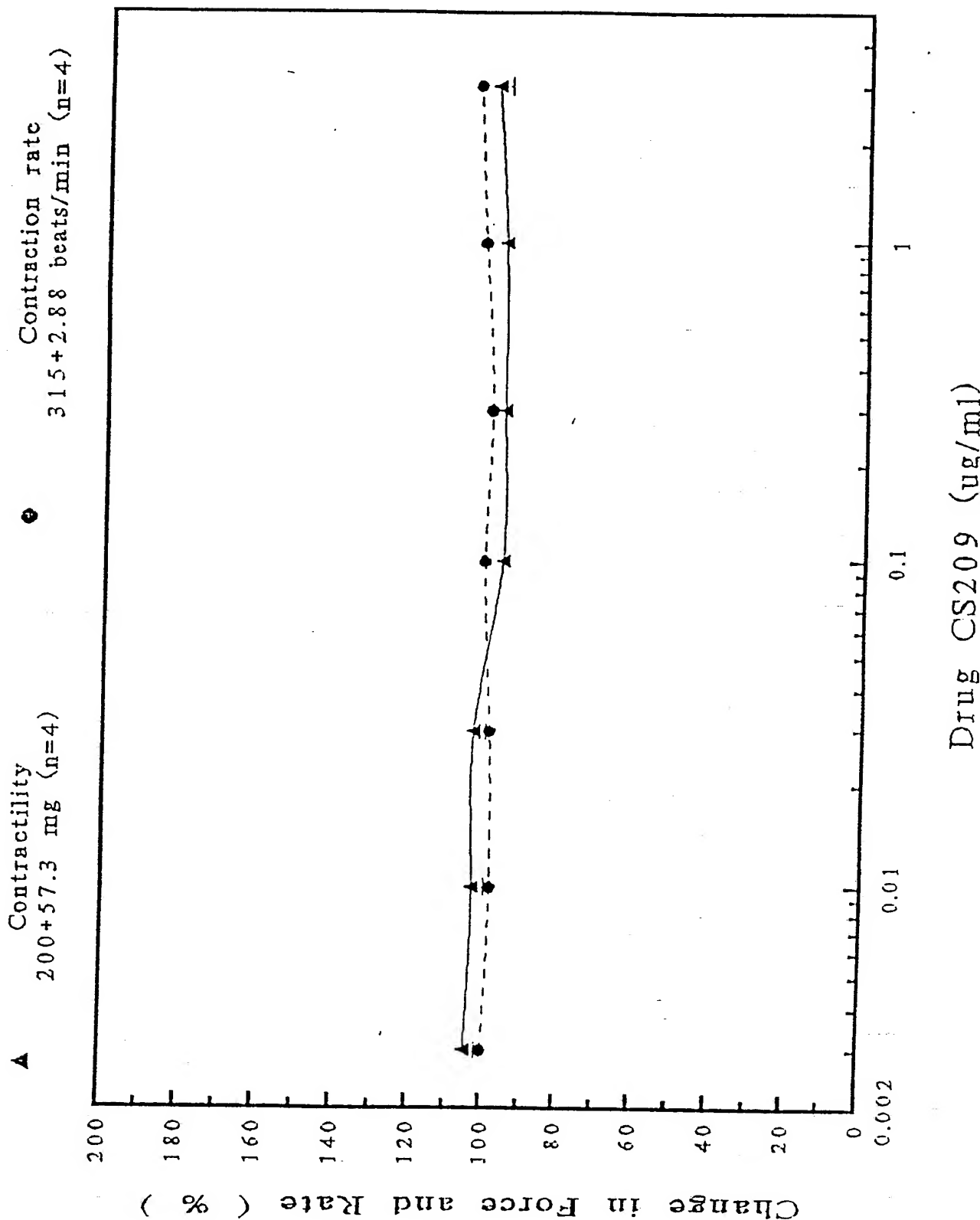


Fig. 54

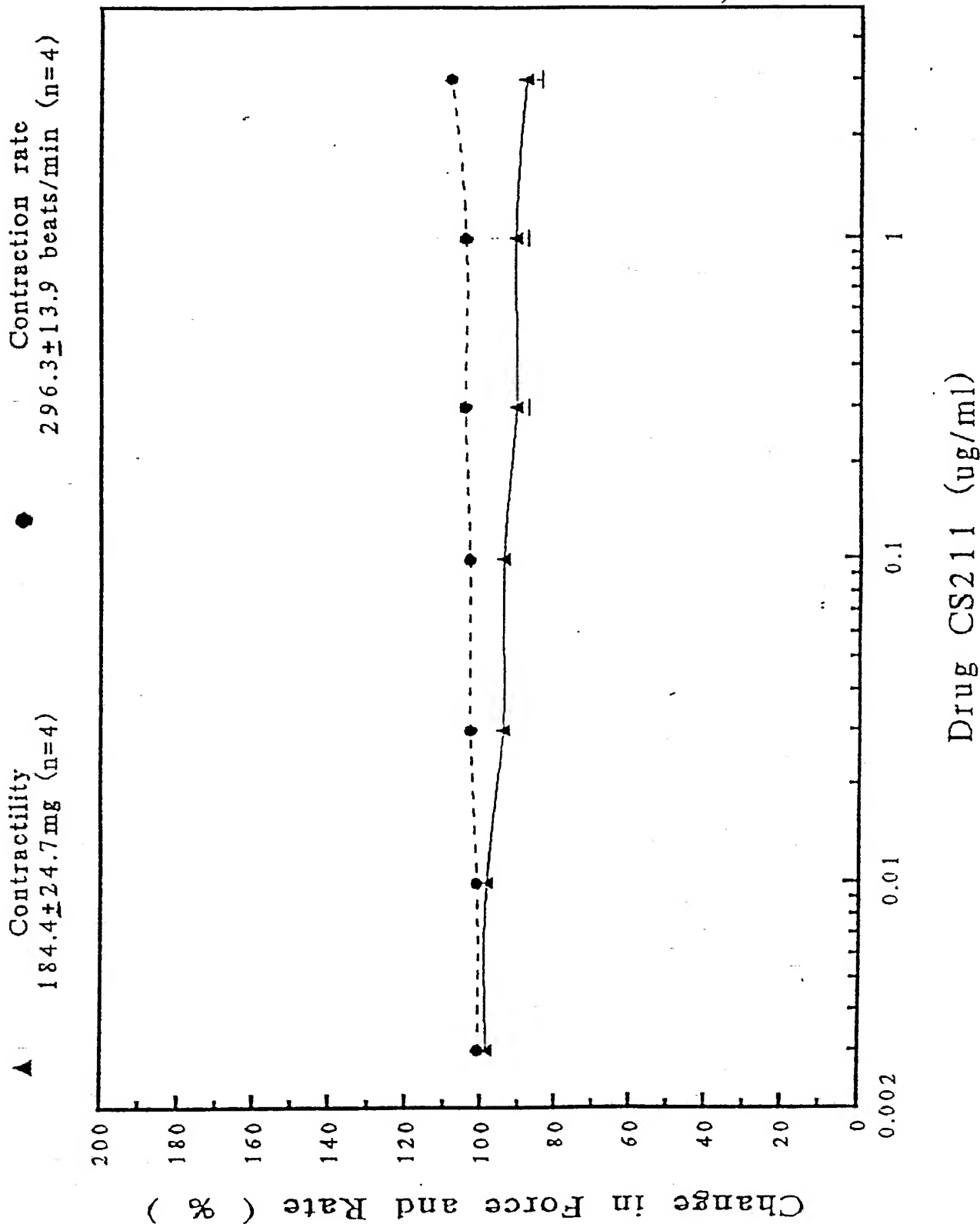
Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS209



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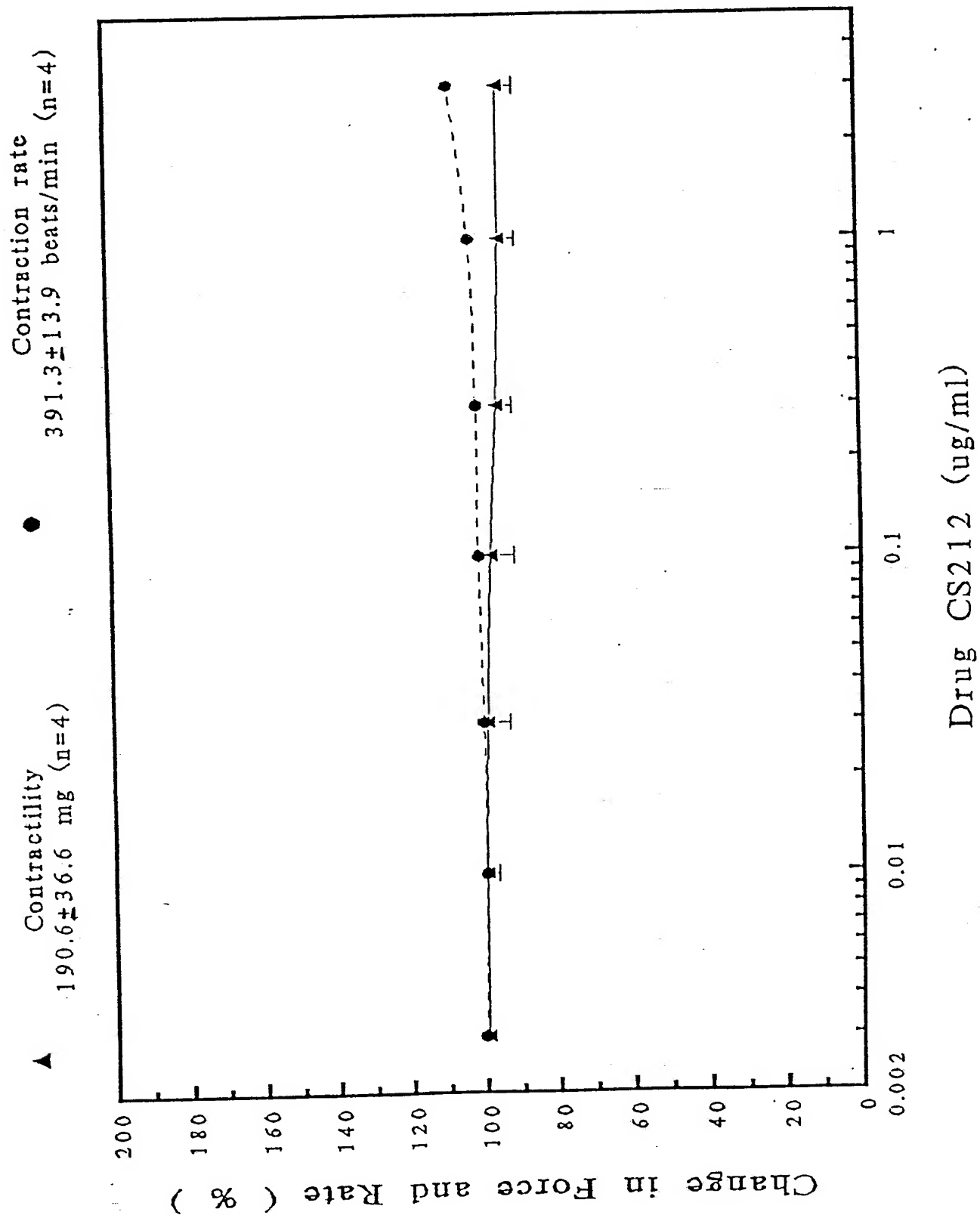
Fig 55

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS211



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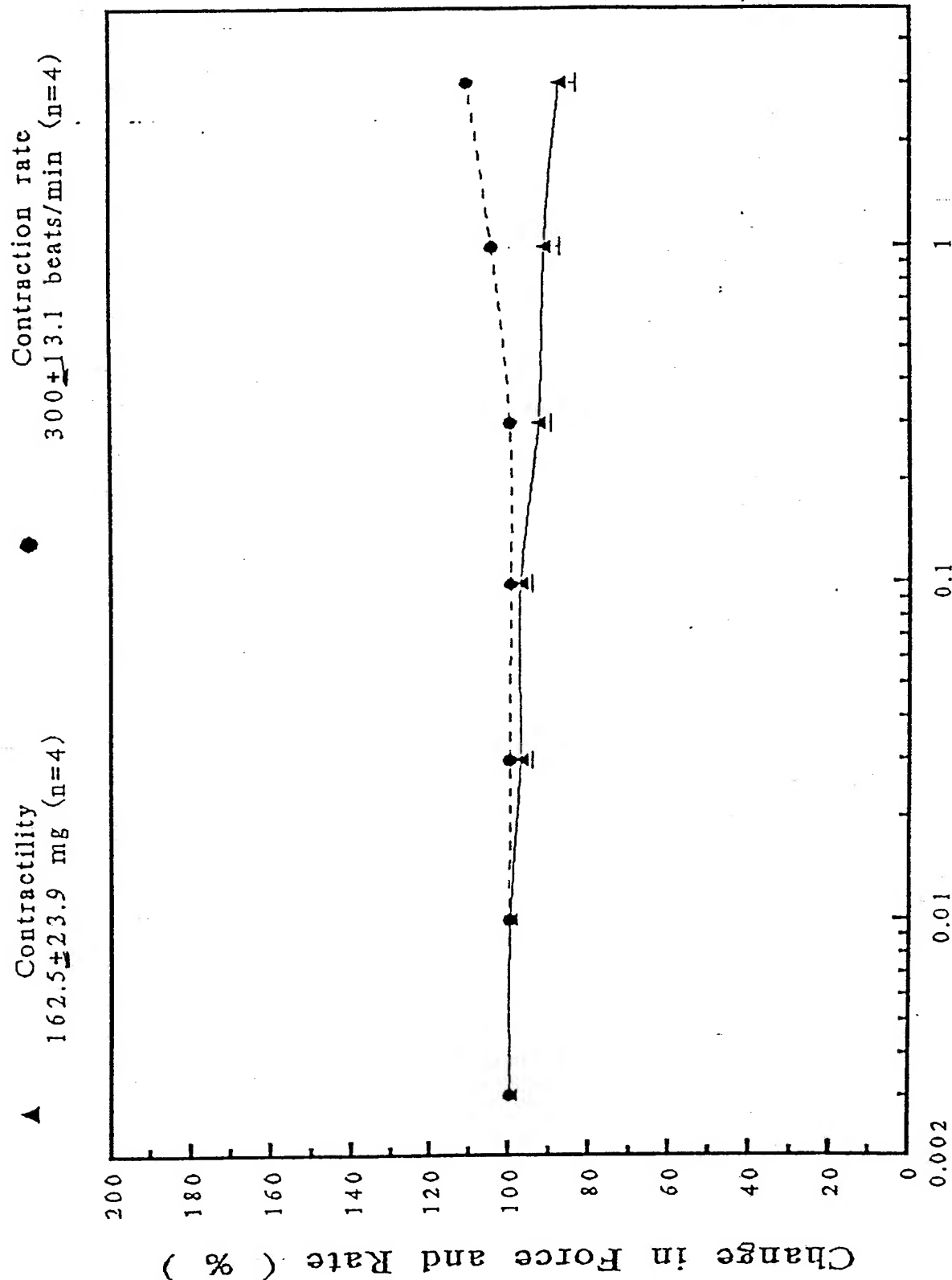
Fig. 56 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS212



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Fig 57

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS213

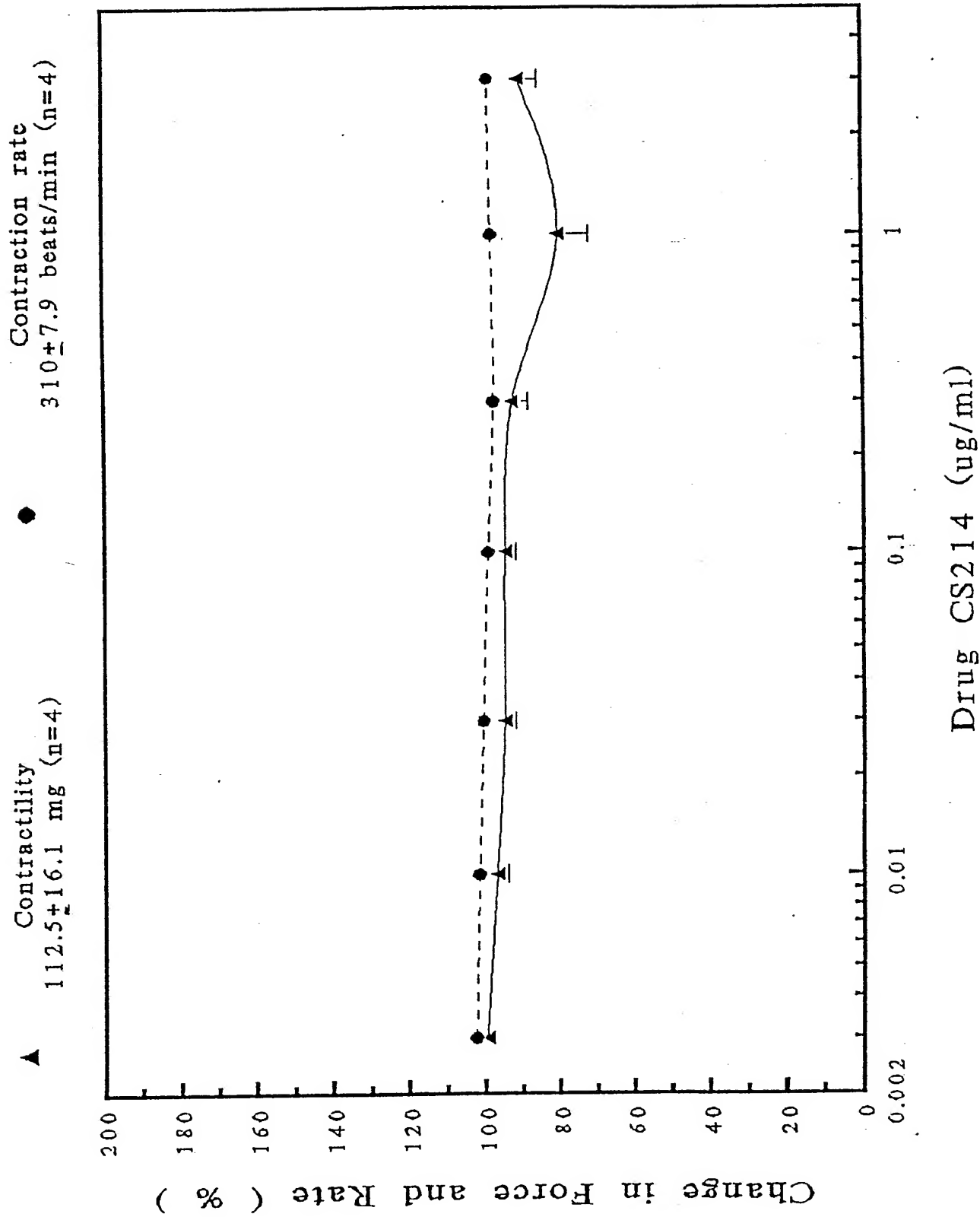


Drug CS213 (ug/ml)

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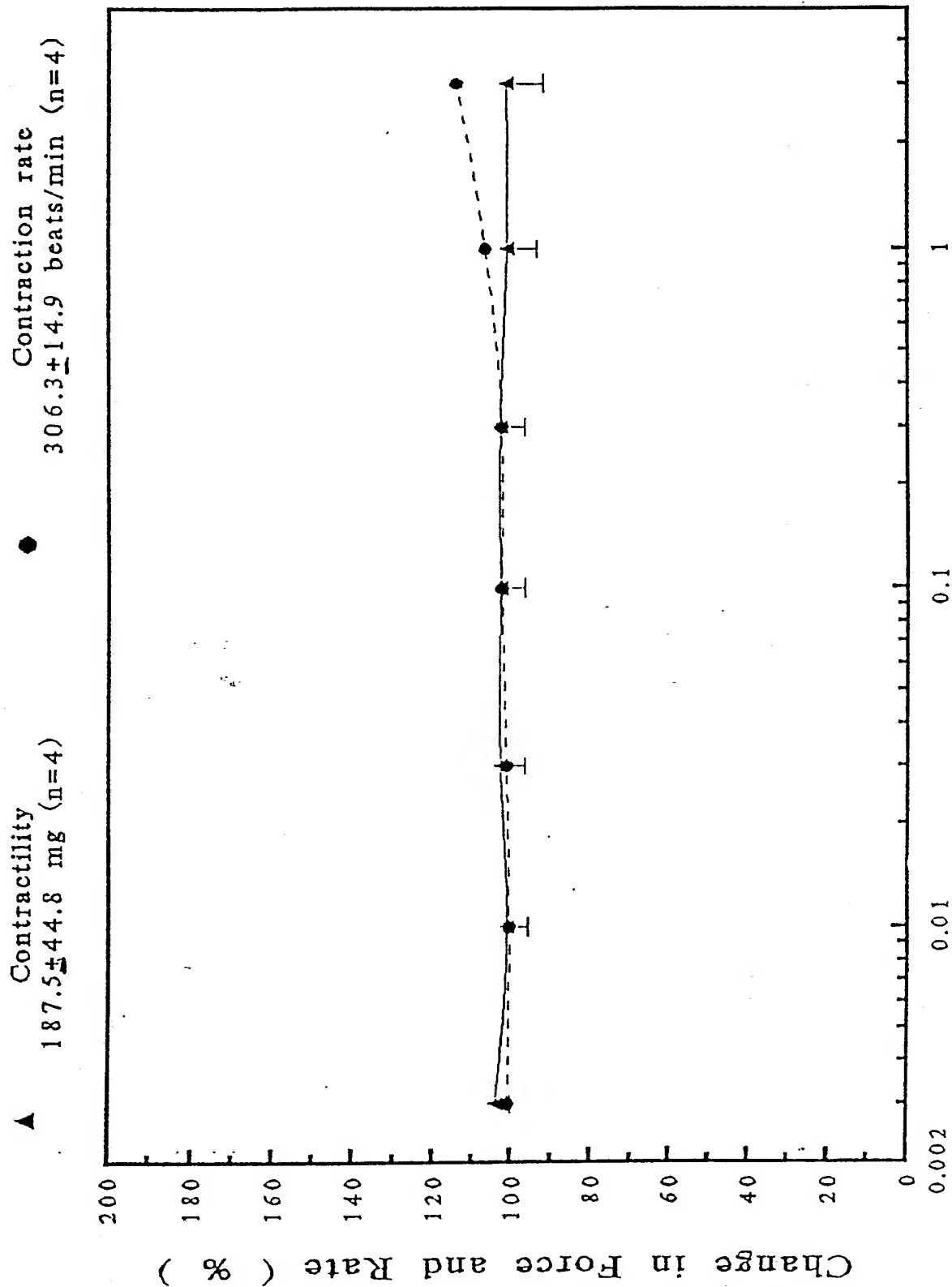
Fig. 58

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS214



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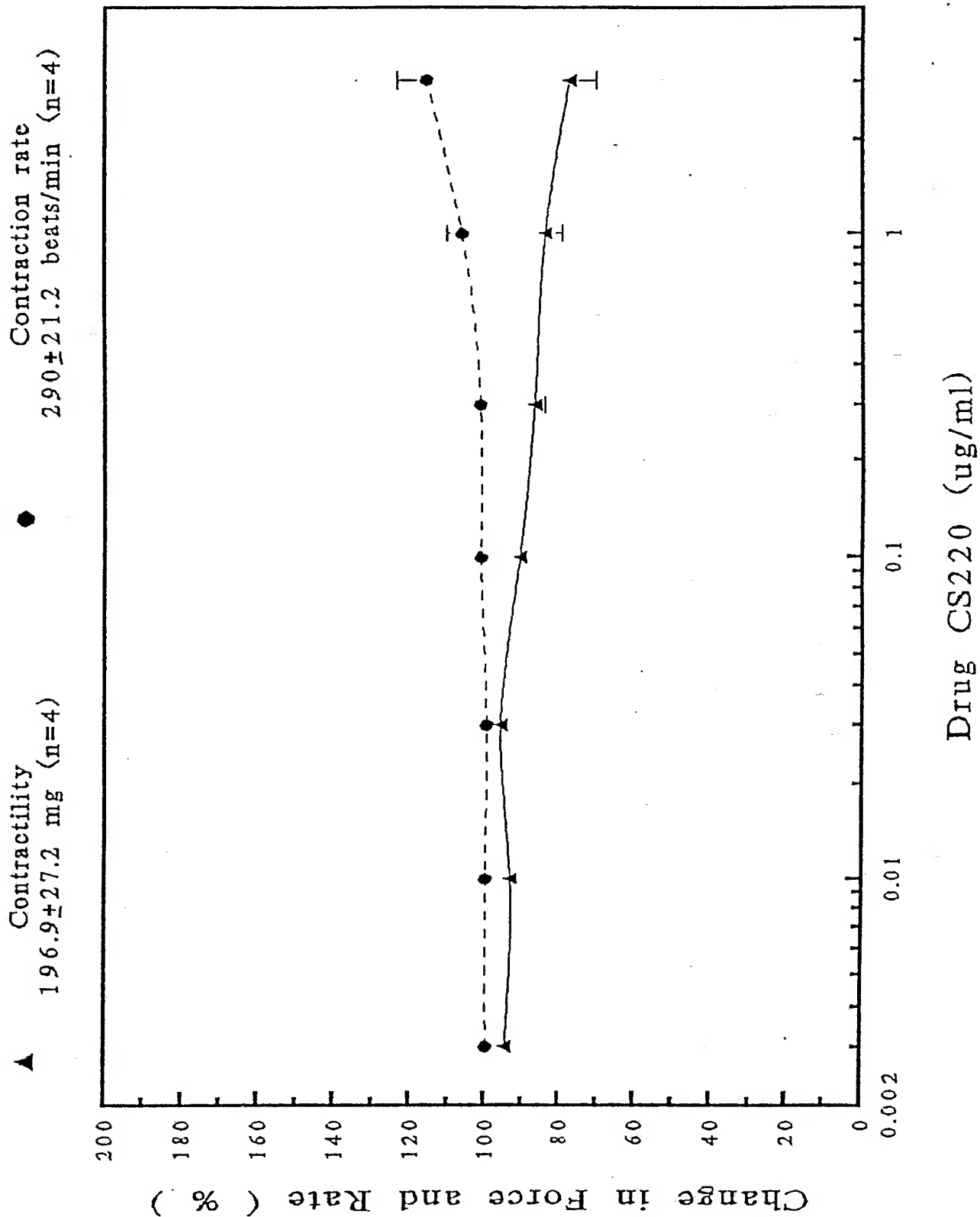
Fig 59 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS215



Drug CS215 (ug/ml)

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Fig. 60 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS2220

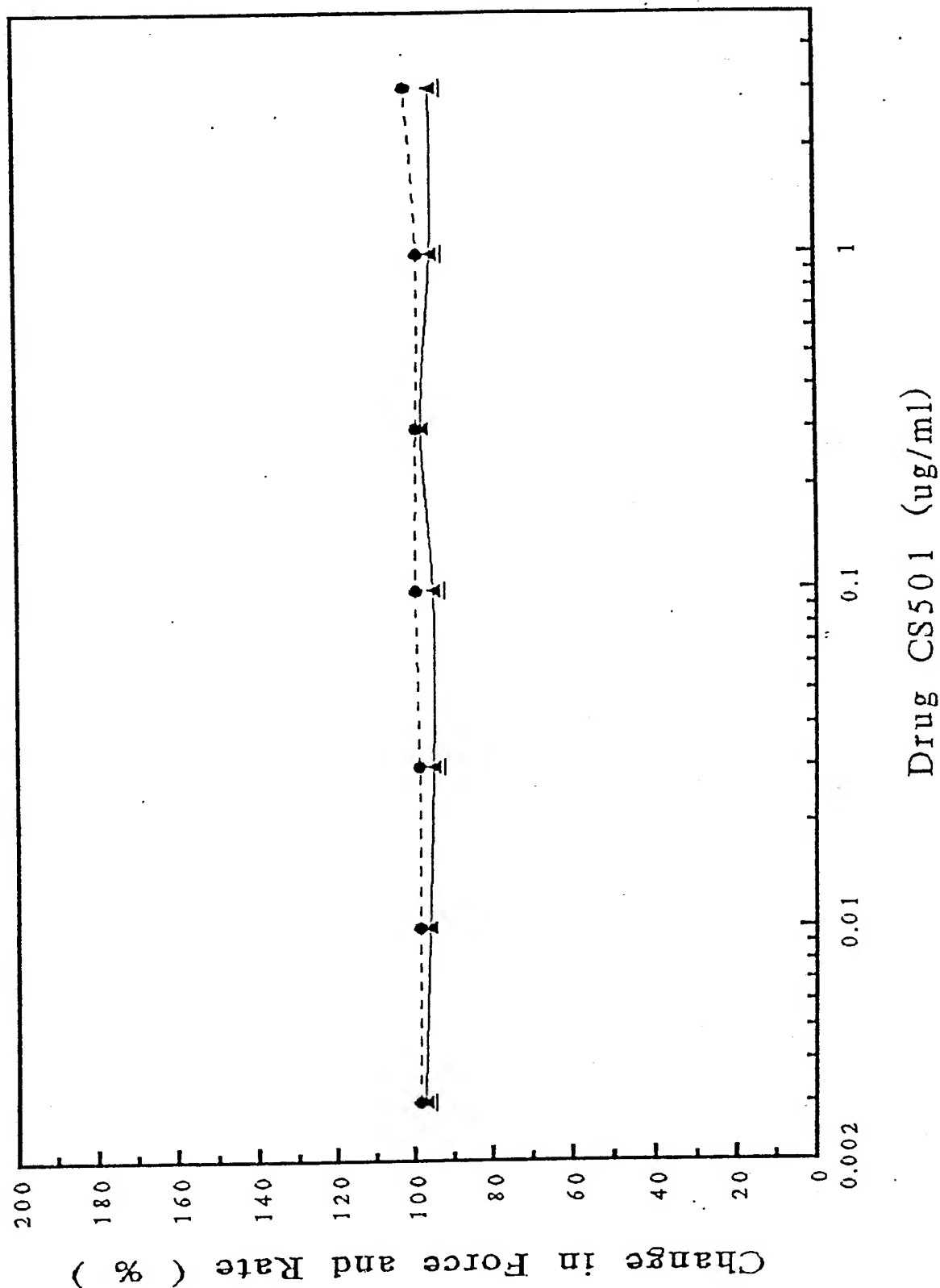


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Fig 61

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS501

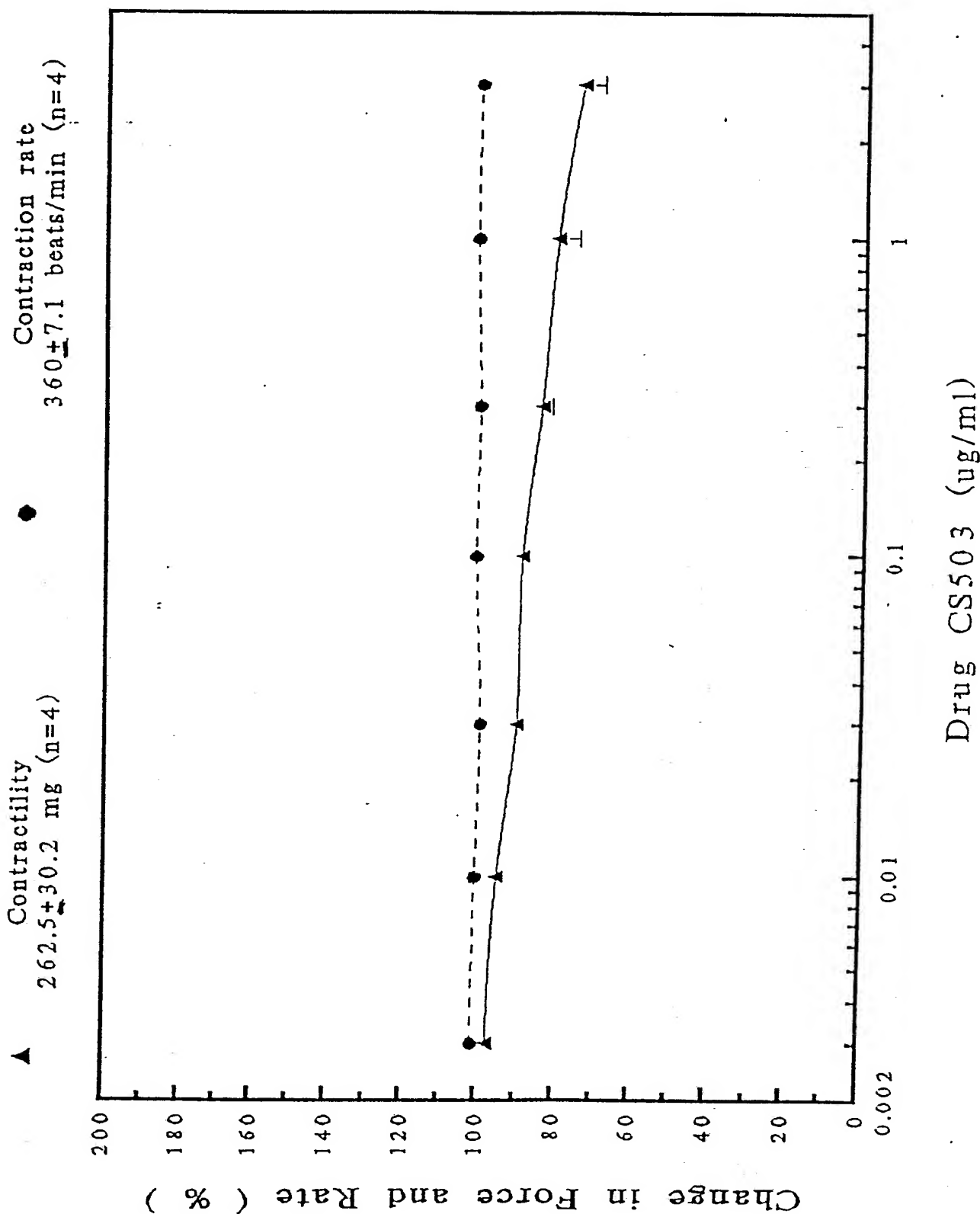
▲ Contractility 118.8 ± 26.3 mg (n=4)      ● Contraction rate 376.3 ± 11.4 beats/min (n=4)



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Fig 62

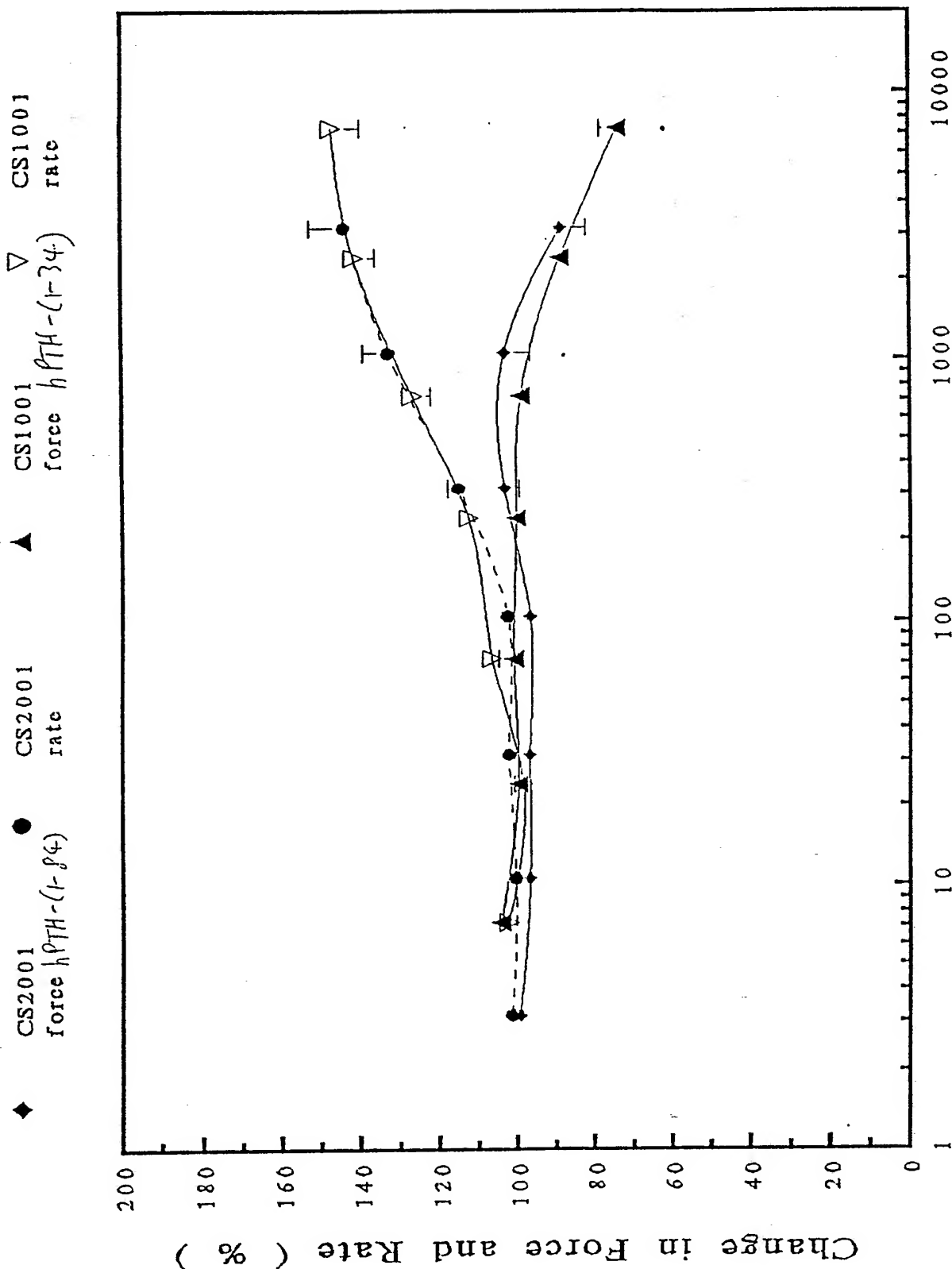
Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS503



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Fig 63

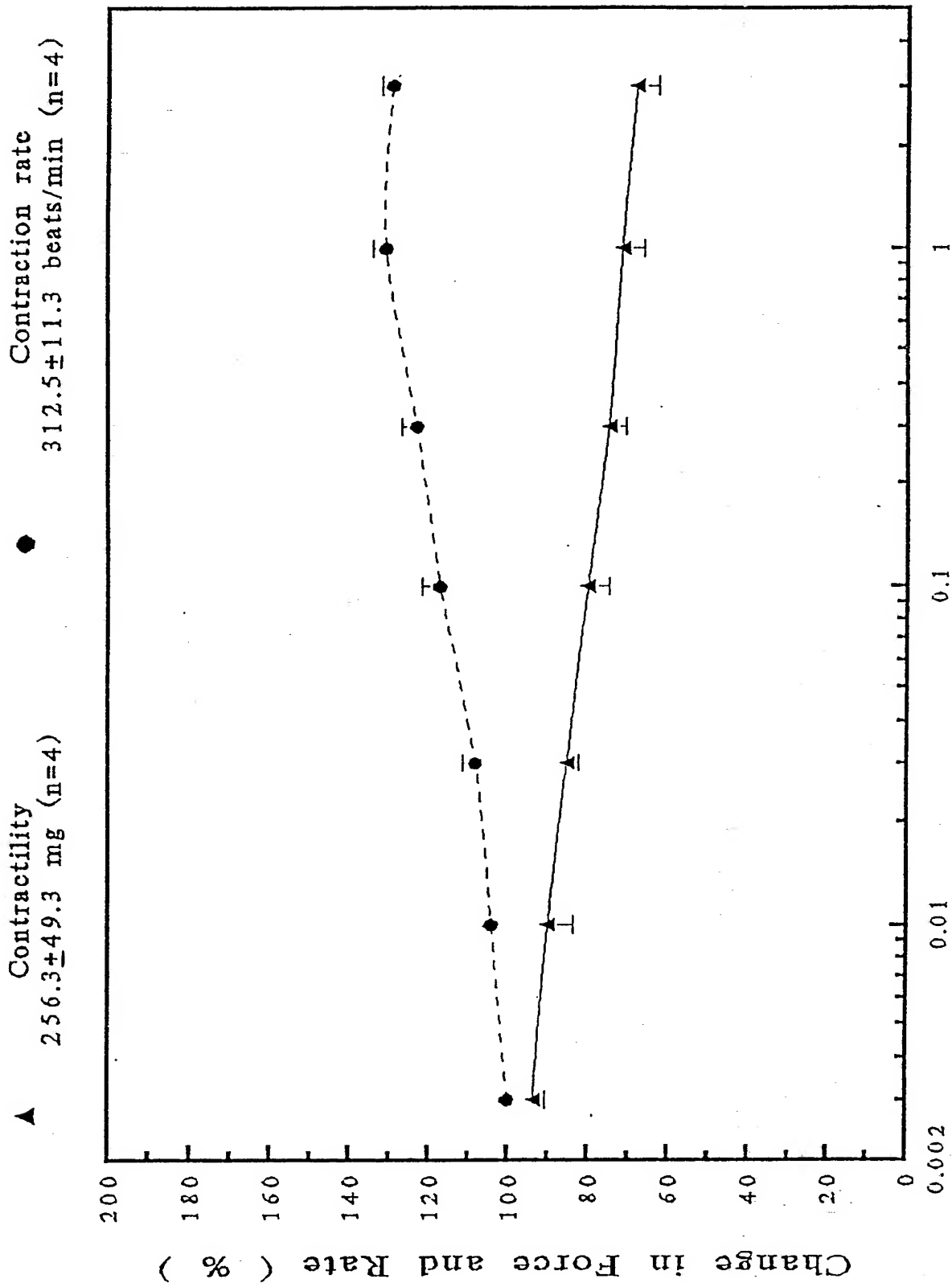
Dose related response curves of right atrial(SD rat) contractility and contraction rate by drug CS1001 CS2001



Drug CS1001 CS2001( $10^{-10}M$ )

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Fig 64 Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS219 [ $\text{R}_{\alpha}^{2,3}$ ]- $\text{H}_2\text{N}-\text{CH}_3$ )

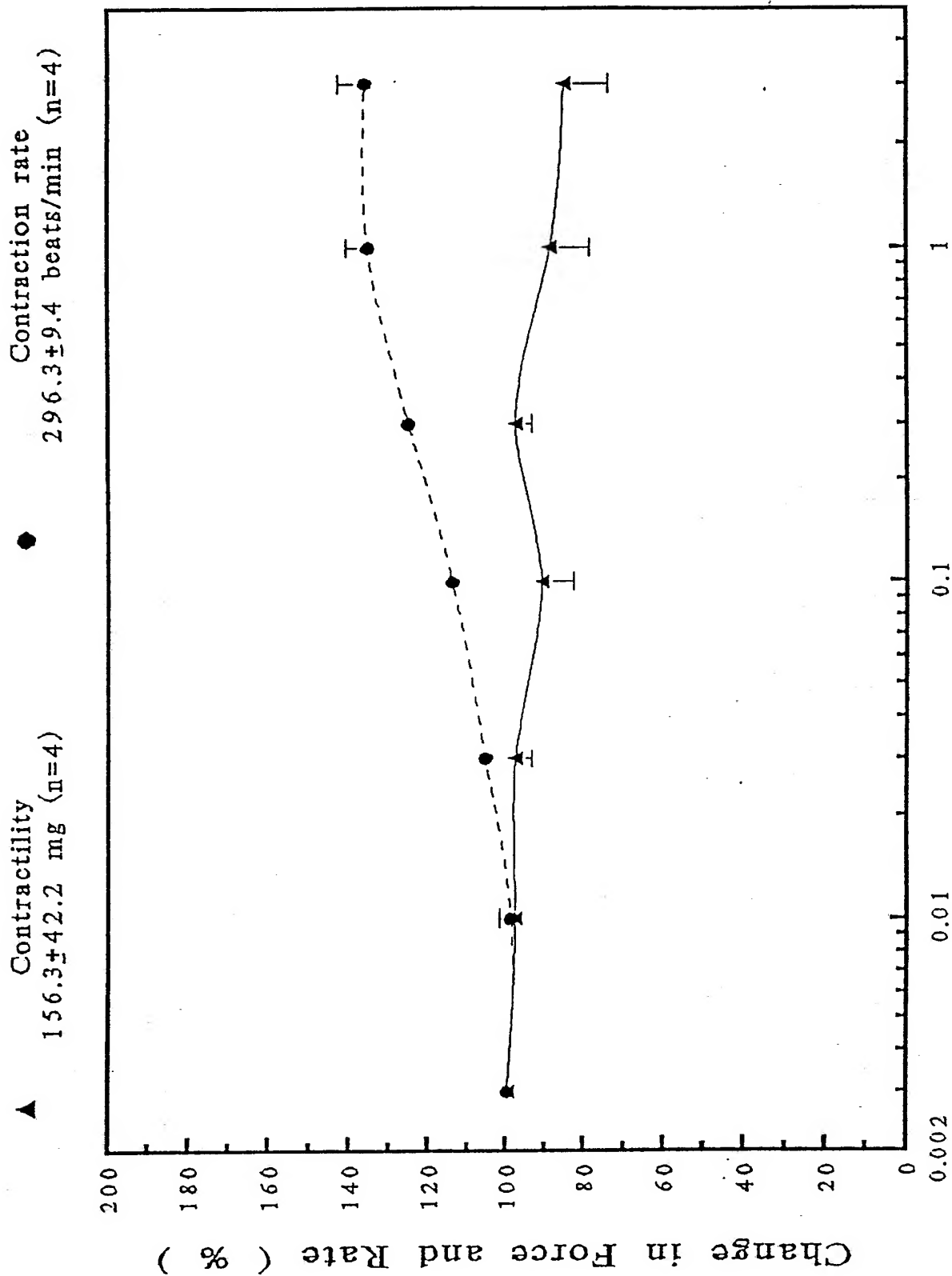


Drug CS219 (ug/ml)

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Fig 65

Dose related response curves of right atrial (SD rat) contractility and contraction rate by drug CS218 [Epr<sup>23</sup>]-k<sup>14</sup>(14)-(124)

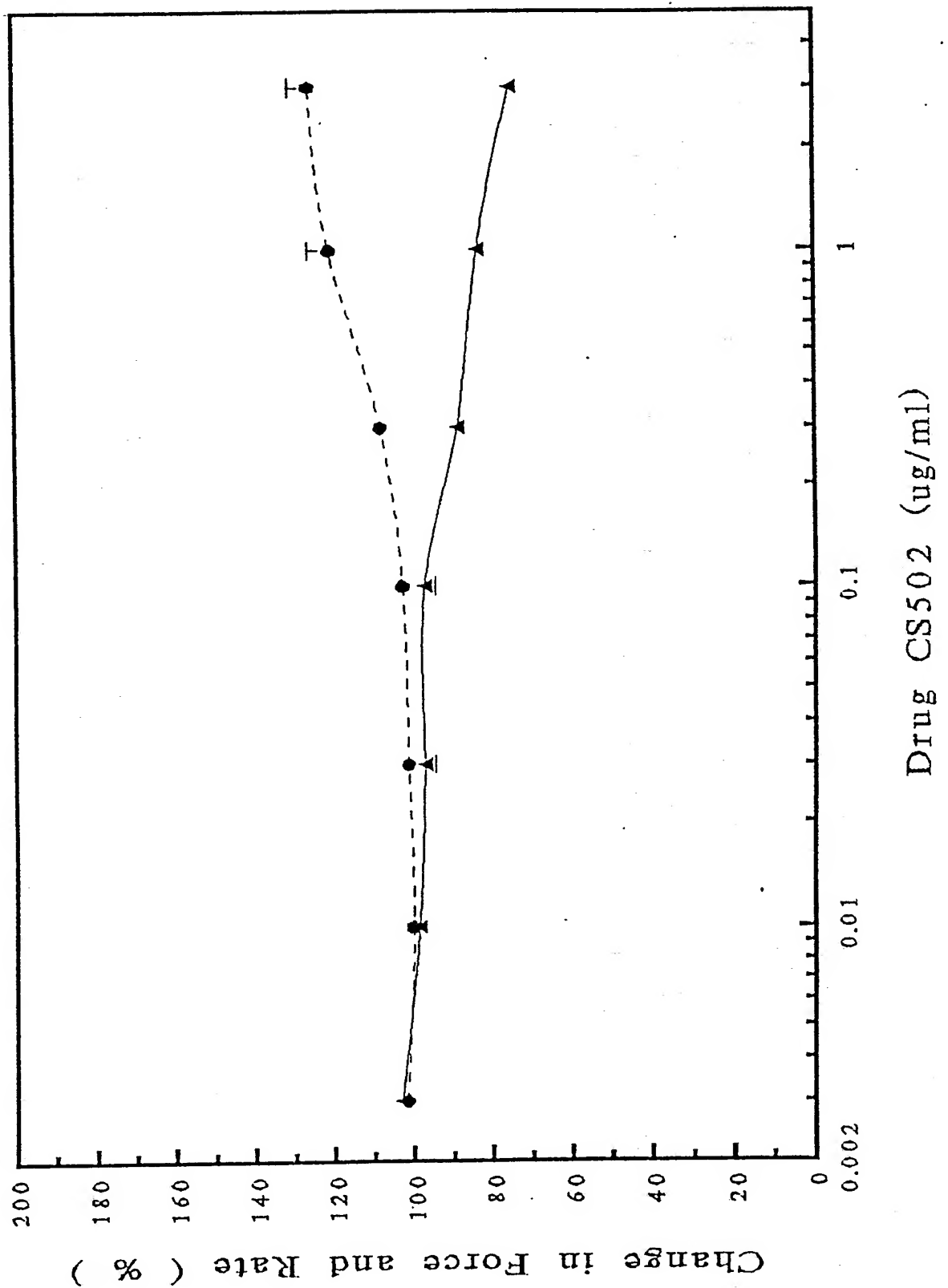


Drug CS218 (ug/ml)

67/67

Fig 66  
Dose related response curves of right atrial (SD rat)  
contractility and contraction rate by drug CS502  
( $2\alpha$  TH-PTH-(1-34))

▲ Contractility 190.6 ± 23.6 mg (n=4)  
● Contraction rate 283.8 ± 12.5 beats/min (n=4)



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US92/08478

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :A61K 37/02, 37/36; C07K 7/10

US CL :530/324, 399; 514/12

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/12,21

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS (Parathyroid and Osteoporosis)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,771,124 (ROSENBLATT et al.) 13 September 1988. See the entire document particularly the abstract.	1-36
Y	US,A, 4,833,125 (NEER et al) 23 May 1989, see the entire document particularly the abstract.	1-36
Y	US,A, 4,086,196 (TREGGAR) 25 April 1978, see the entire document particularly the abstract.	1-36



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be part of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

18 DECEMBER 1992

Date of mailing of the international search report

12 JAN 1993

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Box PCT  
Washington, D.C. 20231

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